# ROMAN BUILDING TECHNIQUES OBSERVED IN THE *MUNICIPIUM* OF BRIGETIO

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**Abstract:** The research excavations in Brigetio at Komárom/Szőny–Vásártér between 1992–2014 unearthed a part of the civil town *(municipium)* with domestic buildings and workshops with several construction phases from the end of the 1st century AD to the second half of the 3rd century AD. Best preserved are the ruins from the Severan era which offer us an insight into the building techniques of the age: adobe walls with stone foundations, mortar floors, hypocaust heating systems, ceilings and vaulted ceilings, roofs covered with ceramic roof tiles, stair cases, door and window openings and wells.

**Keywords:** Brigetio, Roman domestic buildings, strip houses, building techniques, Roman provincial architecture

## INTRODUCTION

The legionary fortress of Brigetio (today Komárom/Szőny, Hungary), alongside the Danube *limes*, was the garrison of Roman troops (mostly the *legio I Adiutrix*) from the 1st century AD to the end of the 4th century AD. The civil settlements around the legionary fortress came into being in the early 2nd century AD: the *canabae legionis* surrounded the *castra legionis* from west and south and the *municipium* lay 2 km more to the west *(Fig. 1)*. The latter was given the rank of *municipium* by 217 AD, when it was called *municipium Brigetionensium Antoninianum*,[1] but according to the latest research, it might have become a *municipium* before 205.[2] In 213/214 Brigetio was subordinated to the governor of Pannonia Inferior[3] and sometime later it was given the rank of *colonia*.[4]

According to the finds, the unearthed domestic buildings in the *municipium* had several building phases from the beginning of the 2nd century AD to the middle of the 3rd century. The heyday of the *municipium* was in the first half of the 3rd century, during the prosperity brought to Pannonia by the Severan dynasty.

The research excavations of the *municipium* of Brigetio at Komárom/Szőny–Vásártér started in 1992 and have been led ever since by László Borhy (Eötvös Loránd University, Head of the Department of Classical and Roman Provincial Archaeology) and Emese Számadó (Director of the György Klapka Museum Komárom). Archaeological investigations have so far brought to light the remains of at least six town houses (*domi*), workshops (bakery, glass-making workshop, metal workshop), two cellars, three wells and a cistern, and segments of two parallel roads *(Fig. 2)*.[5]

[1] CIL III 11007 = RIU 450; Mócsy–Fitz 1990, 62; Borhy 2007, 25.

[2] Mráv 2013, 208–212; Kovács 2007, 146.

[3] Szabó 2000, 97–98.

[4] Borhy–Számadó 2003, 151.

[5] Dobosi–Borhy 2011 and Dobosi 2014.

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## THE SITE

Approximately 1–2% of the 3.5 ha large territory of the *municipium* have been investigated so far, which shed some light on the structure of the settlement. The town was probably surrounded by a city wall[6] with an amphitheatre in the south-western corner.[7] Outside the walls three cemeteries lay along the *limes* road which ran in an east-west direction through the town. The area inside the city walls was divided into *insulae* by roads. The two excavated north-south running roads mark the edges of a 40 m wide *insula* the length of which is unknown. The roads were approximately 3.50-4.00 m wide and covered with stone slabs.

Although a fairly large part of the houses became known, no complete house plans have unfolded yet. Traces of timber structures mark the first construction phase of the settlement, around the turn of the 1st and 2nd centuries AD. Our knowledge of the second-century timber reinforced clay walls of the second phase is still very sketchy. But these early buildings were replaced by adobe houses with stone foundations after the Marcomannic wars, during the Severan era. The richly decorated houses with hypocaust heating systems and wall paintings of the third construction phase from the turn of the 2nd and 3rd centuries AD are now known in detail.

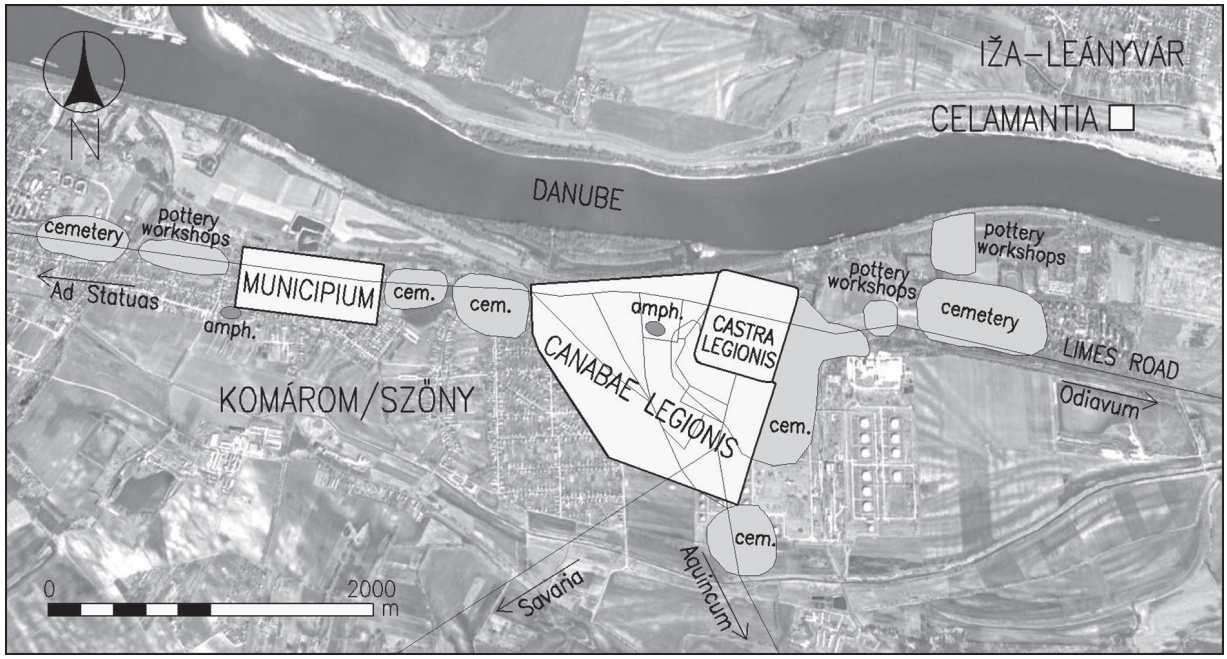


Fig. 1. The topography of Brigetio (L. Dobosi after Dobosi 2014, fig. 1)

The domestic buildings excavated at Brigetio were strip houses (*Streifenhaus*) typical in Pannonia and other northern provinces. In *Insula* 1 the elongated houses of *Domus* I/a, *Domus* I/b and *Domus* V were divided by narrow passageways of 0.70 m. The 11.50 m wide and at least 30 m long *Domus* I/a in the middle of *Insula* 1 probably had its main entrance at its northern end, opening from an east-west oriented road still undiscovered. A long corridor ran in the middle of the house in a north-south direction, with a small courtyard lying on its right side and a series of heated and painted *cubiculi* on its left side, each measuring about 3.80 × 4.20 m. The three large rooms at the southern end of the house were followed by a gravelly backyard and a garden. *Domus* I/b on the left side of *Insula* 1 had large and highly decorated rooms in the excavated area, two of which were heated by a hypocaust heating system. This house also had a gravelly yard at its southern end. *Domus* V on the right side of *Insula* 1 was not a luxurious dwelling house like the other two, but probably a workshop of some kind with its unheated earth floors and undecorated stone-founded

[6] Barkóczi 1951, 6–7.

[7] Borhy 2009.

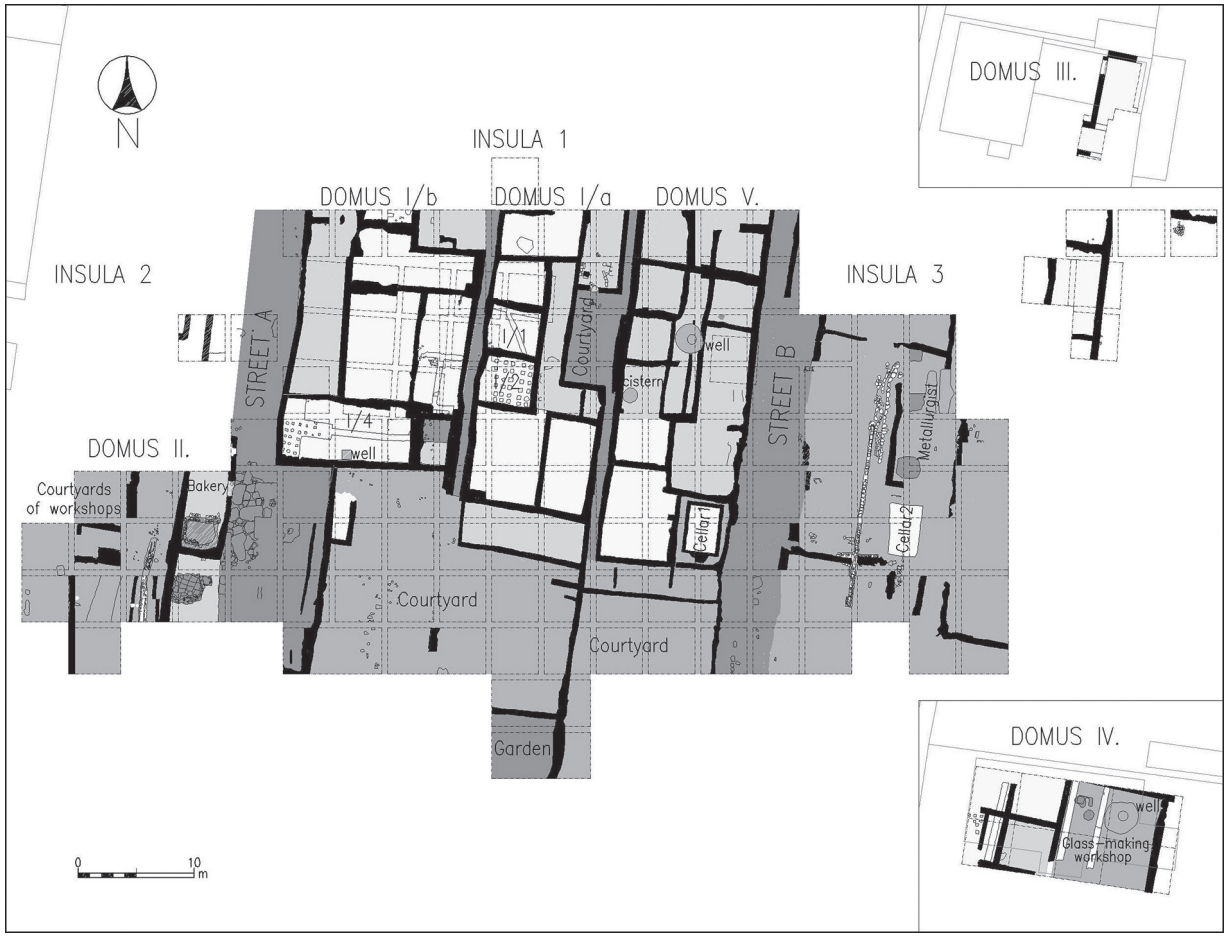


Fig. 2. The *municipium* of Brigetio (L. Dobosi)

adobe walls. Before the third-century house was built, a small cellar, Cellar 1 (2.55 × 3.95 m), lay in the southern part of the excavated area. It was built during the 2nd century AD and filled with earth when *Domus* V was built.[8]

On the east side of *Insula* 2, a bakery was found with its entrance opening on Street A. Behind the bakery courtyards of workshops lay, where the vast amounts of animal bones and the large number of hairpins suggest some form of animal meat, skin and/or bone processing. (The workshop itself has not been found.)[9]

In *Insula* 3, on the east side of Street B, large courtyards were found with canals lined with *tegulae* and a presumed metal workshop with three furnaces. In the southern part of the area another cellar was unearthed, Cellar 2 (4.40 × 2.60 m).[10]

On the east side of Vásártér a tiny part of *Domus* III (2. Vásártér) was investigated in a development-led excavation, which unearthed well-preserved frescoes representing scenes connected to hunting and dining.[11]

At 13 Vásártér parts of *Domus* IV were excavated featuring a second-century glass-making workshop with two furnaces and a well.[12]

The remains excavated at Brigetio help to get a better understanding of how the Roman town houses were constructed in the Danubian province of Pannonia. The aim of this paper is to describe the characteristic building techniques employed in Brigetio.

[8] Szórádi 2010.
[9] Bartus 2001; Bartus 2003.
[10] Borhy *et al.* 2013, 129–130.
[11] Számadó–Borhy 2001.
[12] Dévai–Gelencsér 2012.

## WALLS

Walls built from different materials using different techniques observed in the *municipium* of Brigetio belonged to different construction phases of the settlement. Unfortunately, most of the walls survived only to a modest height, usually not higher than the foundation wall and the plinth. This, of course, is partly due to the perishable nature of the building materials, such as wood or mud bricks, or the re-use of materials, such as stone. Nevertheless, a number of different types of wall constructions were identifiable *(Fig. 3)*.

The remains of the earliest timber buildings of the settlement consist only of postholes and the impressions left by ground beams. These probably belonged to early earth-fast and timber-framed structures and can be dated to the turn of the 1st and 2nd centuries AD. From the few remains it is impossible to reconstruct buildings or building parts, but the orientation of these early walls matched the orientation of the walls of the later construction phases.[13] The postholes measured 300–350 mm in diameter and the impressions of ground beams were 300 mm wide. Large pieces of limestone were laid under the ground beams as foundation and for the levelling of the beam.[14] This was observed at other archaeological sites as well, such as the road station of Sárvár.[15]

The mud and stud walls used during the course of the 2nd century AD were built without any kind of stone foundation from upright logs, walls filled with mud and clay. These walls were 250–300 mm thick and were built on a thin layer of gravel. They were supported by timber uprights as implied by a posthole of 100 mm diameter.

Proper adobe walls with stone foundation and plinth were built from the beginning of the 3rd century AD during the Severan period. According to the finds, a 100–150 mm thick layer of gravel was laid on the bottom of the foundation trenches. Then the c. 250–600 mm deep and 450–600 mm wide foundation trenches were usually filled with a concreted mixture of rubble and limestone. The 400–500 mm high plinth was built in a more careful manner of roughly coursed, irregular shaped stone blocks still with abundant mortar. It was covered by wall plaster both inside and outside. The top of the plinth was levelled with mortar and fragments of *tegulae* were placed in the layer of mortar when needed.[16] The air-dried bricks of the actual walls were approximately $450 \times 300 \times 100$ mm[17] which is the equivalent of the 'Lydian' brick described by Pliny (*Naturalis Historia* XXXV.171.) and Vitruvius (*De architectura* II.3.3.). In consequence of the size of the bricks these walls were built in two thicknesses: the thin ones were 380–400 mm thick when the bricks were laid in stretcher bond (the width of the brick and plaster) the thicker ones 520–550 mm when the bricks were laid in header bond (the length of the brick and plaster). The excavations unearthed a few segments of collapsed adobe walls. The air-dried bricks were bonded by brickearth and covered with at least two layers of mud rendering or lime rendering on each side ($2 \times 40$-50 mm).[18] The rendering was often reinforced at ground level by vertical pieces of *tegulae* set against the wall.

In the earth-and-timber temporary camp of Celamantia near Iža/Leányvár (a few miles from the *municipium* of Brigetio on the left side of the Danube in the former *Barbaricum*) the barracks were also built of air-dried bricks. These bricks, measuring about $250–400 \times 80–150$ mm, were made of local clay and did not contain any deliberately added organic admixtures.[19]

Although in 1892 B. Kuzsinszky started his paper on the building techniques in Aquincum with the words "Romans did not build of mud",[20] we know ever since that, in fact, mud brick walls were commonly used in Roman Pannonia.

In some cases the wall was probably built of stone all the way up. These *opus incertum* walls were made of coursed, irregularly shaped stone blocks and were not thicker than 500–600 mm, but their foundation trenches were deeper (800–900 mm) than those of the adobe walls and the foundation itself consisted of coursed stone blocks rather than concreted rubble. The first few layers of the stone foundation were laid in gravel instead of mortar.

From the *municipium* of Brigetio we only know of one *opus vittatum* wall that was made of carefully shaped rectangular blocks with a very small amount of mortar between the horizontal courses of equal height. This wall was 56–58 cm thick and under the first course of stone blocks there was a 15 cm thick layer of gravel and rubble. The rectangular tufa blocks were c. 300–400 mm long and 100–150 mm high and were laid carefully in regular courses.[21]

[13] Borhy–Számadó 1999, 145.
[14] Excavation diary 2001.
[15] Gabler 1996–1997, 238.
[16] Számadó–Borhy 2001, 85; Borhy *et al.* 2010.
[17] Számadó–Borhy 2001, 88.
[18] Excavation diary 2002.
[19] Hajnalová–Rajtár 2009, 196.
[20] Kuzsinszky 1892, 76.
[21] Borhy *et al.* 2010, 84; Számadó–Borhy 2001, 87.

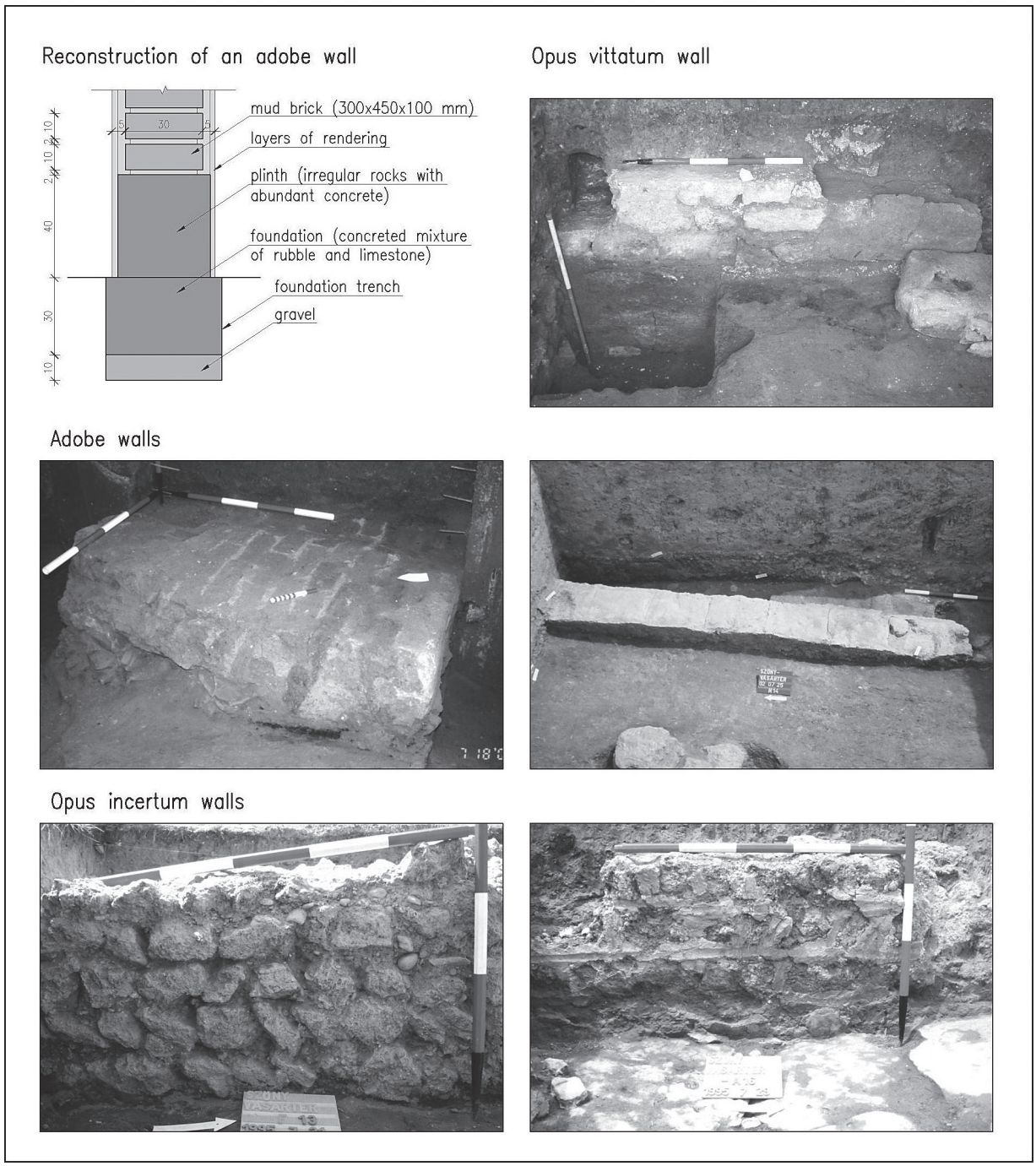


Fig. 3. Wall types in Brigetio (drawing L. Dobosi, photos L. Borhy and E. Számadó)

The use of fired bricks (*later*) in masonry constructions has not been attested in Brigetio.

The original height of the walls and consequently the floor-to-ceiling height of the rooms usually remains unknown. There was one case, however, where the height of the wall could be calculated on the basis of wall paintings. According to the reconstruction of a painted wall in *Domus* III made by E. Harsányi and Zs. Kurovszky the room must have had a floor-to-ceiling height of about 3.70 m.[22] This height might seem a bit high and it is most probable that the average room had a lower ceiling. The floor-to-floor height of standing examples collected by J.-P. Adam in Pompeii and Herculaneum measured between 2.60–3.80 m.[23] In the case of the *domus* of Place Formigé in Gaul L. Tímár calculated the wall heights with different methods. According to his results, the floor-to-ceiling height of the ground floor rooms must have been between 3.19–3.56 m with the exception of the atrium which was 5 m high. The rooms in the upper story were about 2.0–2.5 m high.[24]

## WALL COVERING

As already mentioned above, the walls were rendered with a protective and decorative purpose, as was the practice elsewhere in the Roman world since at least the 3rd century BC.[25] Although Vitruvius recommended seven layers of rendering (*De architectura* VII.3.) and Pliny five layers (*Naturalis Historia* XXXVI.176.), the rendering usually consisted of three layers. In *Domus* I/b of Brigetio the first layer was made of mud mixed with vegetable fibres, then followed a layer of rough lime and sand rendering and a layer of fine lime and sand rendering. The wall was finished with a thin layer of *intonaco*. According to the observations of M. Magyar, the rendering was thicker near the base of the wall and it gradually became thinner with height.[26] In *Domus* III the first two layers of rendering were made of mud mixed with vegetable fibre and these were followed by only one layer of rough lime and sand rendering which also contained vegetable fibre. This wall was also covered with a thin layer of *intonaco*.[27] In both cases the total thicknesses of the rendering was about 40–50 mm.

Both the inside and the outside surfaces of the walls were covered with paintings. Most rooms must have been decorated with ornamental paintings, but some were covered with figurative scenes of high quality.[28] The paintings were made by using both *al fresco* and *al secco* methods and can be dated to the beginning of the 3rd century AD.

## FLOORS

The floors in Roman Brigetio were in no case luxurious, not even in the highly decorated, heated rooms. As elsewhere in Pannonia, the average room had an earth floor or mortar floor (*opus signinum*) and the outside areas, yards were spread with gravel. The compacted earth or gravel surfaces identified at the sites, however, might have been in some cases only the foundation of the actual floor *(Fig. 4)*.

The high status rooms of domestic buildings were usually provided with an *opus signinum* floor, made like the description of Vitruvius (*De architectura* VII.1.1-3.). According to Vitruvius, a well-founded *opus signinum* floor had to be at least 1 foot thick. On the carefully compacted earth a layer of bigger rocks were to be laid, then a layer of gravel mixed in lime mortar. Then another layer of gravel with a high proportion of crushed and broken tile in lime mortar followed. The final polish gave the floor a reddish finish. Vitruvius explicitly drew attention to the thorough compaction of the layers, without which the floor was bound to sink and break.

In Brigetio the mortar floors were built following the above description, except that not such a high proportion of crushed tiles were used in the aggregate, and therefore the finished floor had more of a white (beige) colour rather than red. In Room I/2. of *Domus* I/a the mortar floor under the hypocaust was made as follows: onto the compacted earth a 100 mm thick layer of gravel was spread, then a layer of bigger rocks were laid, which was followed by a 150 mm thick layer of gravel mixed in lime mortar and finished with a polish.[29] The floor of Room I/4.

[22] Borhy *et al.* 2010, 101.
[23] Adam 2007, 200–205.
[24] Tímár 2011, 55–56.
[25] Adam 2007, 216.
[26] Borhy *et al.* 2010, 52–53.
[27] Borhy *et al.* 2010, 101.
[28] More about the wall paintings: Borhy *et al.* 2010; Borhy 2001; Borhy 2007.
[29] Excavation diary 1996.

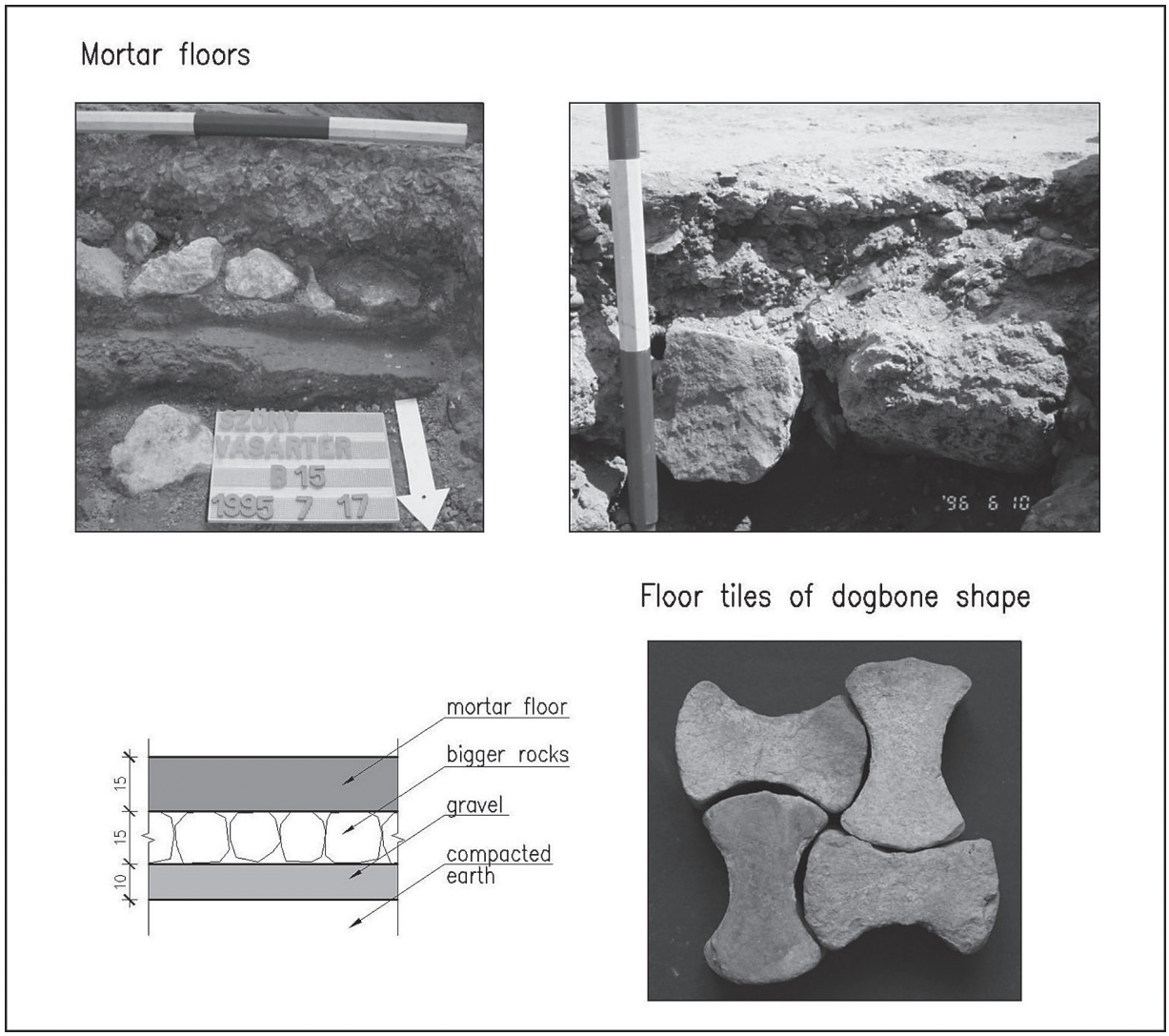


Fig. 4. Floors (drawing L. Dobosi, photos L. Borhy and L. Dobosi)

in *Domus* I/b was built in a similar manner. Here the bigger rocks were placed directly onto the compacted earth, on top of which a layer of gravel and crushed tiles mixed in lime mortar was poured. The floor was then polished.[30]

Based on the Samian ware finds the *opus signinum* floors of Brigetio can be dated to the Severan era, around the beginning of the 3rd century AD.[31]

In spite of the good quality of the mortar floors, some of them did sink eventually due to long use. The broken parts of the floors were mended using mud infill and, if necessary, the bigger holes were filled with fragments of *tegulae*.[32]

In working and service areas, such as workrooms and corridors earth floors were standard. This form of floor was called '*pavimenta barbarica atque subtegulanea*' by Pliny (*Naturalis Historia* XXXVI.185.) and it was certainly the oldest and simplest of all floor types.

There is a chance that some of the earth floors were covered with timber planks, although their use has not yet been attested in Brigetio. Timber floors were rare in Italy, but they were common in the northern provinces.

[30] Excavation diary 1995.
[31] Dobosi 2014, 16.
[32] Számadó–Borhy 2001, 89.

According to D. Perring they were widely used in Britain,[33] and Adam quotes an example from Bavay.[34] In Aquincum (Pannonia), 300 mm wide planks covered the earth floor in Room 8 in the Villa at Csúcshegy.[35]

Compacted earth or gravel surfaces could have also carried tile floors. A wide variety of shapes and sizes were suitable for this purpose, like the *bessalis* (2/3 ft × 2/3 ft), the *pedalis* (1 ft × 1 ft), the *lydion* (1 ft × 1.5 ft) or the *sesquipedalis* (1.5 ft × 1.5 ft).[36] Instead of these standard bricks, special paving tiles were applied in Brigetio. All but one of the dozen floor tiles were of dogbone shape from the same mould, measuring c. 47 × 75 mm. According to G. Brodribb the small floor tiles of different geometrical shapes were more common in Northern Italy and the Danube provinces.[37] We know of all kinds of paving tiles from Aquincum: different sizes of dogbone shapes, squares, hexagons, octogons and also 'fish fingers' laid in herringbone pattern (*opus spicatum*).[38] From the Villa at Zsennye small rhomboid floor tiles were recovered.[39] M. George pointed out that in Northern Italy fitted hexagonal bricks were the most popular, although other forms, including *opus spicatum*, also occurred.[40]

O*pus sectile* pavements (stone inlay composed of imported marble) and mosaics have not been unearthed in the *municipium* yet, but a very small fragment of a mosaic floor is known from somewhere in Brigetio.[41]

## HYPOCAUSTS

Some of the rooms with mortar floors were heated by underfloor heating systems, where hot air coming from an outside furnace or *praefurnium* was circulated beneath the floor. The invention of the hypocaust heating was attributed to C. Sergius Orata (lived in the 1st century BC), but this belief is not supported by the written and archaeological evidence.[42] Instead, hypocaust heating systems probably originated from Greece, where the first underground heating ducts (Gortys, Olympia, Syracuse) date back to the 3rd century BC.[43]

Vitruvius described hypocausts in connection with baths (*De architectura* V.10.2.), because this type of heating first appeared in the *caldarium* of Roman baths. According to his recommendation, the bottom floor had to be paved with *sesquipedales*, then small, 2 ft high pillars had to be raised using bricks 8 × 8 inches large. The pillars were to be covered by tiles 2 ft square (*bipedales*), which carried the pavement.

Archaeological evidence confirms that hypocausts were indeed built in this manner, although in a great variety of shapes, sizes and building materials. Observations by J-P. Adam showed that the height of the heating channels ranged from c. 400 to 700 mm,[44] but we know of several cases in Pannonia where the height of the channel reached or even exceeded 1 m.[45] The pillars or *pilae* could be built from tiles or stone blocks and could be square, circular or octagonal.[46] There were three main types of hypocaust systems regarding the underfloor arrangement: pillar hypocausts (the floor was raised by a number of *pilae*), channel hypocausts (the hot air was directed along channels) and composite hypocausts (a combination of channels and a pillared chamber).[47] There are examples of all the three types in Brigetio (*Fig. 5*).

Under Room I/2. of *Domus* I/a lay a pillar hypocaust. The 3.90 × 4.20 m large surface of the floor was supported by 36 *pilae*, 6 pillars in each of the 6 rows. The pillars were about 0.50 mm high, made of three 300 × 300 × 150 mm stone blocks. These were probably covered by *bipedales* carrying the mortar floor, which had collapsed ever since.[48]

From this room, a channeled hypocaust spread the hot air in a northerly direction into the adjacent Room I/1. The 0.40 m wide and 0.50 m high channel crossed the room diagonally.

Room I/4. of *Domus* I/b., a large reception room measuring 4.60 × 11.00 m, had a composite hypocaust. The 0.55 m wide heating channel ran along the long axis of the room then, taking up a T-shape, widened into a

[33] Perring 2002, 126.
[34] Adam 2007, 196.
[35] Nagy 1937, 36.
[36] Brodribb 1987, 34–41.
[37] Brodribb 1987, 53–54.
[38] Kuzsinszky 1892, 103; Havas 2005, catalogue.
[39] Buócz 2006, 48.
[40] George 1997, 24.
[41] Kind notification of L. Borhy.
[42] Fagan 1996, 56–64.
[43] Adam 2007, 265.
[44] Adam 2007, 265–268.
[45] Kuzsinszky 1892, 112–114.
[46] Adam 2007, 265–268; Perring 2002, 128.
[47] Perring 2002, 128.
[48] Excavation diary 1995 and 1996.

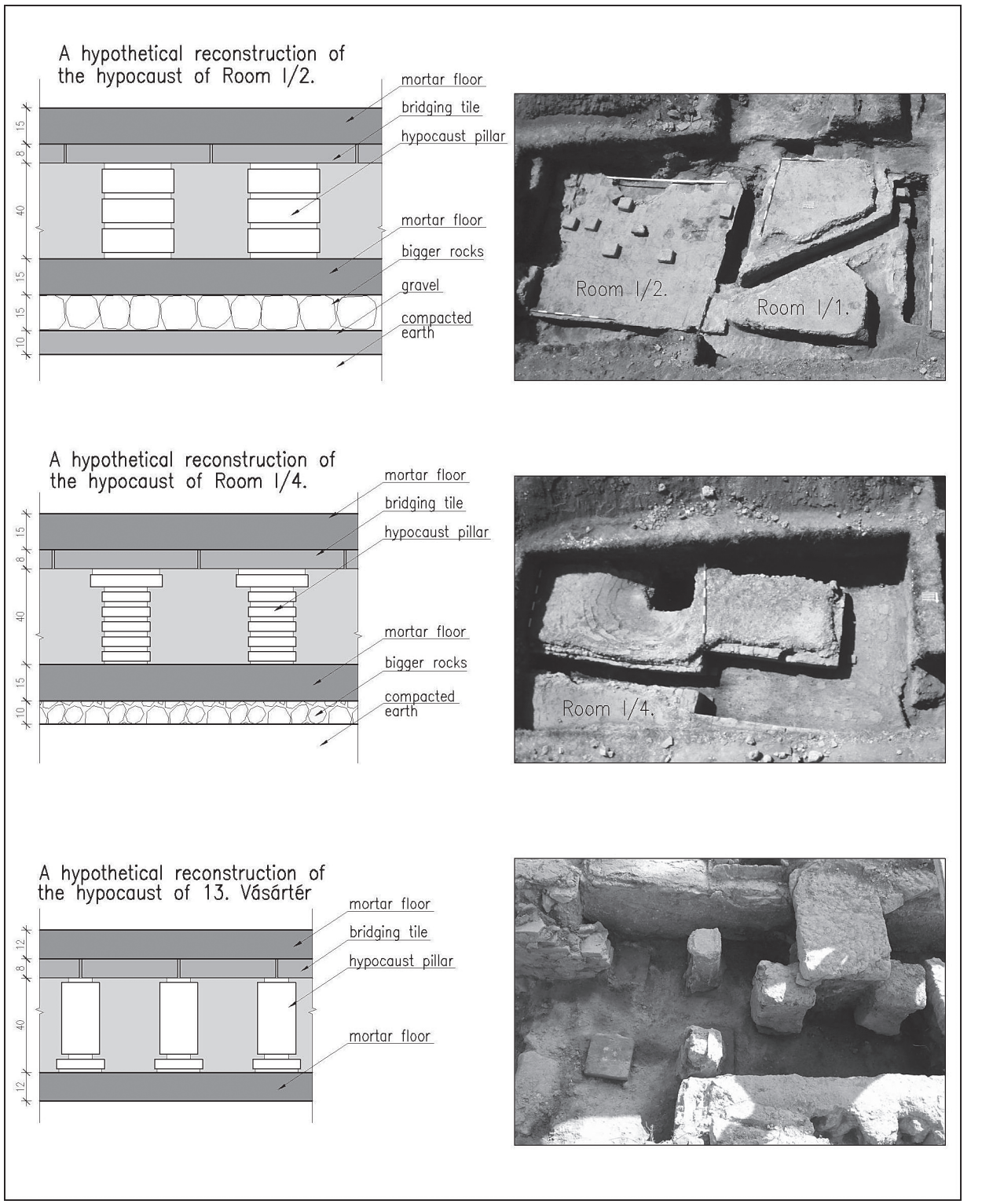


Fig. 5. Hypocaust heating systems (drawings L. Dobosi, photos L. Borhy and Á. Gelencsér)

pillared chamber at the end. The heating channel and the chamber must have been about 400 mm high, and the 22 pillars of the chamber were made of 200 × 200 × 40 mm tiles.[49]

A smaller hypocaust in good condition was unearthed in one of the rooms of *Domus* IV. The *suspensura* over the 400 mm high heating chamber was held by pillars made of mortar filled *tubuli*. A square tile was placed under each *tubulus*, and on top of them big square flagstones were laid.[50]

In all four cases the sides of the heating channels and chambers were built of bricks with their surface carefully rendered, and the floor of the hypocaust was a polished mortar floor. All four hypocausts were built at around the same time, in the beginning of the 3rd century AD, in the Severan era.[51]

In Brigetio there has been no evidence to suggest the use of monolithic stone pillars in hypocausts frequently found elsewhere in Pannonia. The reason of this, of course, is that suitable volcanic stone material is not readily found around Brigetio, whereas for example trachyt was available in Aquincum.[52]

In Brigetio, as in other Roman sites, a number of *tubulus* fragments were recovered from the debris, but none were found *in situ*. The *tubuli* or *tubi,* otherwise known as box tiles or box-flue tiles were the invention of the 1st century AD, Seneca mentions them as novelty of his lifetime (Seneca, *Epistulae*, XC, 25.). They were fixed vertically to the walls of the heated room, so that the hot air could circulate up through the walls and thus provide wall-heating as well, as it is generally believed.[53] However, an experiment led by F. Kretzschmer in Saalburg in 1951 showed that the tubulated walls did not actually radiate heat to the room, because the hot air flowing up them cooled down immediately below room temperature.[54] Nevertheless, the columns of *tubuli* set in the walls were essential to the efficient working of a hypocaust, since they ensured the sufficient ventilation of the air. According to Kretzschmer's experiment, at least four corner or mid-wall vents or chimneys of *tubuli* were needed in each heated room.[55]

## CEILINGS

Our knowledge of how the ceilings in domestic buildings were constructed is primarily based on the finds of Pompeii and Herculaneum, but we have evidence in Brigetio as well.

Since the span to cover never exceeded 6 metres in Brigetio, we can assume that a row of joists were set in sockets of the masonry, as we can still see in Pompeii.[56] In the case of Cellar 1, where the sockets of the joists could still be seen at the time of the excavation, the sockets were 160 mm wide, 200 mm high with an interval of 550–600 mm between them (*Fig. 6*). The span to cover was 2.55 m and the floor-to-ceiling height of the cellar was 1.70 m. The joists set in the sockets must have been usually covered by a boarding on both the upper and lower sides. The wood planks were nailed at right-angles to the joists, sometimes in more than one layer.

A fortunate find in Cellar 2 shows the preserved boarding of a ceiling. The wood planks had a width of 160–220 mm and they were probably laid in two layers (*Fig. 6*).[57]

As in Pompeii, we also find vaulted rooms in Brigetio. Room I/1. in *Domus* I/a was covered by a barrel vault based on the curved pieces of painted plaster collected from the room.[58] The painted ceiling, reconstructed by Zs. Kurovszky and E. Harsányi had a cross-section of an almost half-circle and was covered by a mythological scene featuring Pégasos and Andromeda with the personification of the seasons in the corners.[59] The barrel vault itself, however, was not a real vault, but an arched ceiling, constructed in the same way as the flat ceilings described above *(Fig. 6)*. This type of 'vault' was common in the Vesuvian cities as well,[60] and the way of construction was discussed by Vitruvius at length (*De Architectura* VII, 3.1-3.). He called it *camarae*, and it involved a series of joists set in sockets, which were placed in the wall along a curved line. To the underside of the joists small planks of wood were nailed, then it was lined with reeds and rendered. This was, in fact, a very simple way to create an impressive effect.

According to the observations of the restorers, in the case of the vault in Brigetio there were seven parallel fault lines in the first layer of rendering, which marked the joining lines of the wood planks nailed at right-angles

[49] Excavation diary 1994 and 1995.
[50] Excavation diary 2006.
[51] Dobosi 2014, 15–17.
[52] Kuzsinszky 1892, 85-86, 110–115.
[53] Brodribb 1987, 70–79.
[54] Kretzschmer 1953, 31.
[55] Kretzschmer 1953, 21–40.
[56] Adam 2007, 197.
[57] Borhy *et al.* 2013, 130.
[58] Borhy *et al.* 2010, 30–32.
[59] Borhy *et al.* 2010, 41.
[60] Adam 2007, 199–200.

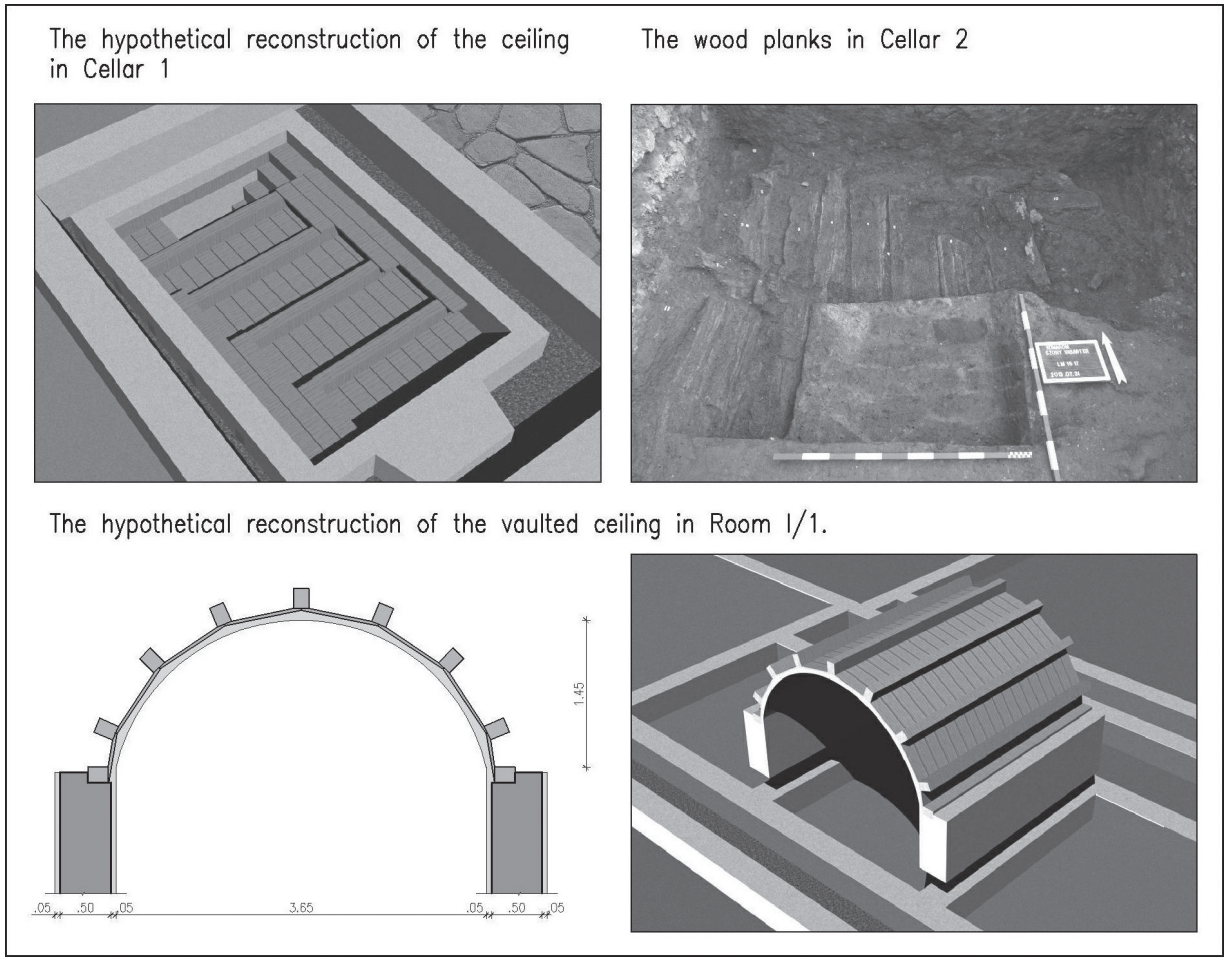


Fig. 6. Ceilings in Brigetio (drawings L. Dobosi, photo D. Bartus)

to seven joists. The wood planks were first rendered with a layer of mud with reed mixed into it, then a rough layer of mortar made by mixing sand, lime and pebbles followed. The third layer was a fine sand and lime mortar which was covered by the *intonaco* made of almost pure lime. The total thickness of the rendering added up to about 40–50 mm hiding the fault lines of the 'vault'.[61]

We can be fairly certain, that the houses unearthed in Brigetio were single-storey, at least there is no evidence of upper stories.

## ROOFS

Although Roman roofs hardly ever survive *in situ*, there are a few known examples from the Vesuvian cities (a small structure in the peristyle of the Villa dei Misteri in Pompeii, the roof of the House of Telaio in Herculaneum, Villa Regina at Boscoreale and the House of Julius Polybius at Pompeii).[62] These provide information about the use of ceramic roof tiles but give little help when it comes to the reconstruction of roof timbering in Roman provincial buildings. But as simple domestic buildings generally don't need complex roof carpentry, we can assume, that coupled close roofs were used most of the time and king posts in more sophisticated cases.[63]

[61] Borhy 2001, 98.
[62] Brodribb 1987, 8–9; Van Buren 1941, 469.
[63] Adam 2007, 205–212; Perring 2002, 119–120.

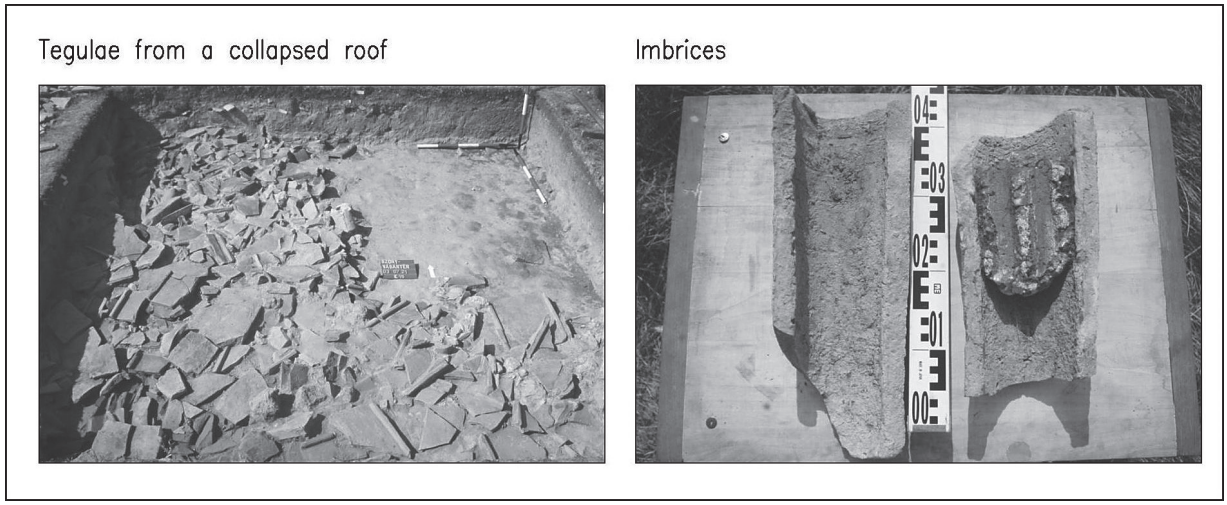


Fig. 7. Roman ceramic roof tiles in Brigetio (photos L. Borhy)

The roofs in Brigetio were covered with ceramic roof tiles *(Fig. 7)*. There is no sign of any other roofing material, such as stone slates, timber roof shingles or reed thatch, which occur at other Roman sites.[64] *Tegulae*, flat roof tiles laid overlapping one another and *imbrices*, covering the junction between two *tegulae* have been found in vast quantities in Brigetio. The gaps between the tiles were filled with mortar making the roof waterproof. As the ceramic tiles were produced in individual kilns throughout the Empire, their shapes and sizes were not standarderized. In Brigetio two sizes of *tegulae* have so far been identified, the bigger being 450 × 590 mm and the smaller 410 × 560 mm.[65] (In comparison, the smallest *tegulae* found in Rome were 390 × 460 mm and the largest ever found – on the roof of the *sacellum* at Paestum – measured 750 × 1105 mm.)[66] The *tegulae* had flanges along their longer sides with cutaways at their upper and lower end. The form of the lower cutaway varied by region and in time, but in Brigetio only one type has been documented, the Warry B form.[67] The *imbrices* had a cone shape and their one documented size measured 450 mm in length with a smaller diameter of 128 mm and a larger of 196 mm.[68] The line of the *imbrices* along the gutter usually ended with an antefix, but in Brigetio only one small fragment has been identified as an antefix. Instead, at the end of the line of the *imbrices*, the mortar that filled the gap between the tiles was evened and painted white. The small number of nails found in the roof debris show that only the bottom row of *tegulae* were nailed to the roof timbering, as assumed to be the case elsewhere.[69]

The pitch of Roman roofs is generally thought to be low, like the modern roofs in Mediterranean countries.[70] The pitch of the roof, however, must have varied according to the climate of a province and the roofing material used. In Roman Britain, for example, there is evidence for slate roofs pitched at 40 degrees (Carsington), 45 degrees (Welney) and even 47.5 degrees (Meonstoke). But the ceramic tile roof of Redlands Farm had a pitch of only 22.5 degrees, proved by its collapsed gable-end wall.[71] Another tile roof in Augusta Raurica must have been about 25–30 degrees steep.[72] In Brigetio the *tegulae* overlapped by about 100 mm, which means that the roof was waterproof over 20 degrees. And since the *tegulae* do not need to be fixed with nails until an angle of at least 30 degrees,[73] we can say that a roof pitch between 20–30 degrees seems a realistic estimate in Brigetio.

[64] Adam 2007, 214–215; Perring 2002, 120–121.
[65] Számadó–Borhy 2001, 87.
[66] Adam 2007, 213.
[67] Warry 2006, 3–4.
[68] Kovács 2002, 107.
[69] Brodribb 1987, 11; Hufschmid 1996, 215.
[70] Hanson 1982, 181.
[71] Perring 2002, 120; King–Potter 1990.
[72] Hufschmid 1996, 215.
[73] Brodribb 1987, 10.

## STAIRS

The wall plaster in Cellar 1 preserved the impression of a wooden staircase *(Fig. 8)*. The first step of the stair was formed by elevating the mortar covering the floor by about 100–150 mm. Behind the step, there was a little trench measuring 700 × 300 mm with a depth of 350 mm, which hosted the strings (two rising pieces of wood). The strings supported the solid wooden steps, the traces of which were visible in the rendering of the wall. Consequently, the staircase was 0.70 m wide and each of the seven steps were about 200–270 mm high and 200–300 mm

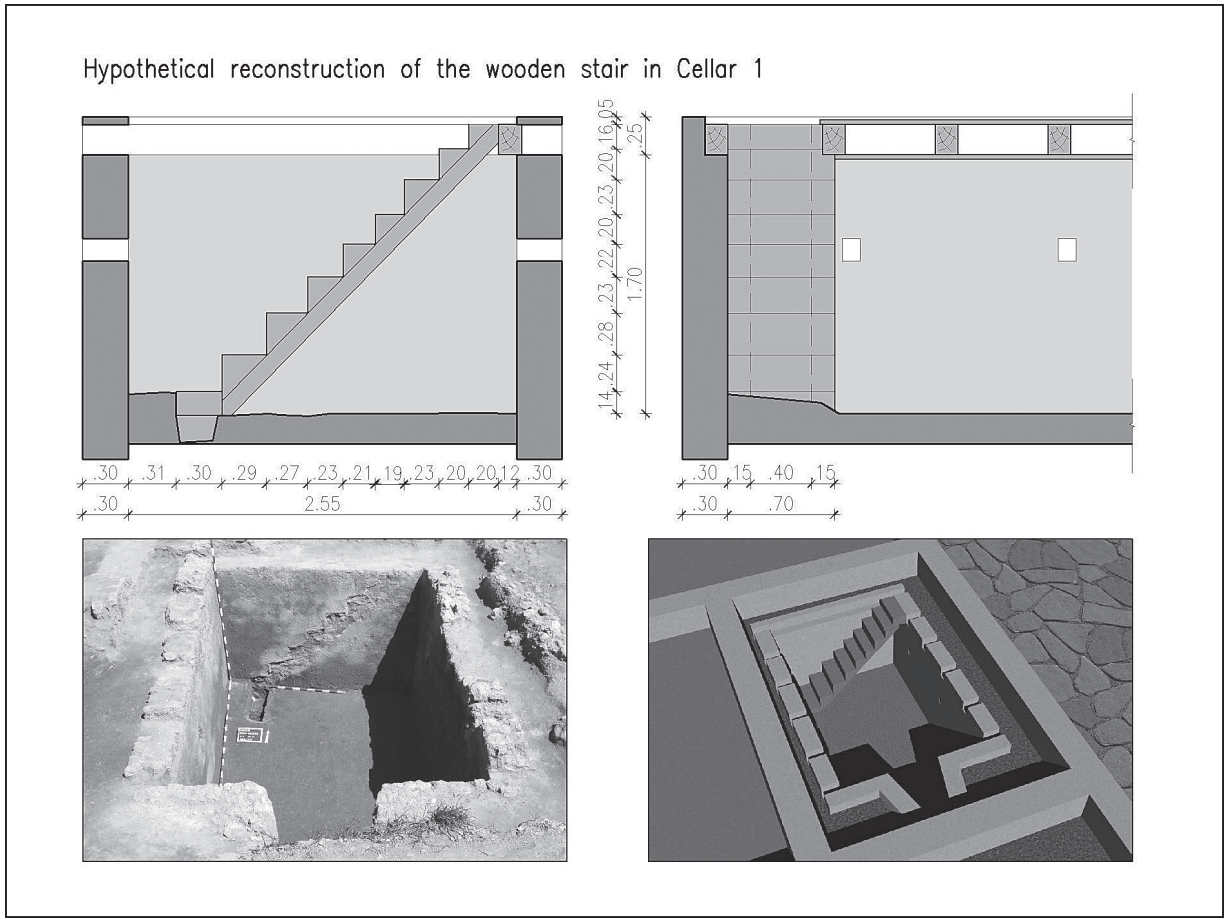


Fig. 8. The wooden stair in Brigetio (drawings L. Dobosi, photo D. Bartus)

deep. This gives us an incline of about 45 degrees which is quite steep, but not unusual in Roman times. The wooden stairs with similar construction were about 38–40 degrees steep in the Vesuvian cities. In Herculaneum (region IV. no. 20) a 1.23 m wide stair had solid wooden steps 220 mm high and 250 mm deep, which means an incline of about 40 degrees. In the House of Faun at Pompeii (VI,12,2) the stair was 0.86 m wide and the steps were 260 mm high and 320 mm deep with an incline of around 38 degrees.[74] A solid wooden stair in *Insula* 39 in Augusta Raurica measured about 0.90–1.00 m in width and it was about 35 degrees steep (the steps must have been about 180 mm high and 320 mm deep).[75]

[74] ADAM 2007, 200–205.

[75] HUFSCHMID–TISSOT-JORDAN 2013, 32–34.

Parts of a staircase were preserved in a cellar in Aquincum, where the steps were made of mud and originally covered with wood planks.[76]

Cellar 1 in Brigetio, and therefore the wooden stair was most probably built during the 2nd century AD, and destroyed when a new house was built above at the beginning of the 3rd century AD.[77]

## DOORS AND WINDOWS

We can rarely find the remains of Roman doors or especially windows, but we can still collect information about how they were constructed. Paradoxically we have less information about the doors from Brigetio than about windows. Even if the opening of the door is found, there remained only an impression in the mortar of the monolithic doorsill (threshold). Because of this, only the sizes of the openings are known: they were between 1.25–1.40 m, which meant double doors. Some of the doors had a threshold of wood instead of stone. These 220–360 mm wide, 175–190 mm thick and 1.23–1.38 m long pieces of wood were placed in the fresh mortar and a 150 mm long segment on each side of them were built in the wall, so that the actual openings were 0.93–1.08 m wide.[78]

The remains of a splayed window were found *in situ* in the southern wall of Cellar 1 *(Fig. 9)*. The window sill was 0.95 m high, the opening was 1.08 m wide on the inside and 0.50 m on the outside and it was 0.90 m deep. The total height and thus the way of bridging the opening remains unknown. There is no sign of any kind of window frame in the opening. Two windows of similar kind were unearthed in Aquincum, in the cellar of the so-called Painter's House.[79]

There is no other window found in Brigetio, but during the years of excavation a number of window glass fragments came to light. The colourless or greenish fragments were 2.5–4 mm thick with one side being plane and the other rough.[80] The reason for this lies in the production process: the fluid/liquid glass was smoothed in a mould sprinkled with sand or glass powder. An example from Pompeii showed that the rough side of the glass looked towards the outside.[81] Another consequence of the production process was that the glass panes were thicker around the edges than in the middle. The use of window glass in the Roman Empire must have appeared during the 1st century AD, because they have been found in Pompeii but were not mentioned by Vitruvius.[82] Also, Seneca referred to it as a novelty of his lifetime (Seneca, *Epistulae*, XC, 25.). In Brigetio only cast window glasses were found, since blown window glass only appeared in the 4th century AD,[83] when the *municipium* of Brigetio was no longer inhabited.

Most of the windows are thought to have been small, set high and protected and not overlooking the street.[84] The smallest reconstructed square windows from the western provinces were $190 \times 250$ mm (Pompeii), $200 \times 400$ mm (Carnuntum) or $260 \times 270$ mm (Limoges), the largest ones, however, measured up to $700 \times 1000$ mm (Pompeii) or $800 \times 800$ mm (Herculaneum), which means a considerable size, indeed.[85] In Roman Britain glass panes up to 400 mm across were found.[86] The fragments from Brigetio could not be joined together.

The glass panes were usually set in the wall by simply fixing them with mud, lime mortar or gypsum without any kind of a frame. The only function of these windows was to let some light inside, for the quality of the glass at this time did not allow one to see through them. Window frames of wood, bronze or iron were employed throughout the western provinces, but there is no sign of framing employed in Brigetio. Some of the windows must have been openable by the end of the 1st century AD.[87]

## WELLS, CISTERNS AND CHANNELS

There is no sign of an aqueduct in the *municipium* of Brigetio, in spite of the fact that there was one in the legionary camp. This aqueduct, which brought fresh water from Tata to Brigetio, was about 20 km long and was

[76] Láng 2011a, 33; Láng 2011b, 30.
[77] Dobosi 2014, 20.
[78] Számadó–Borhy 2001, 87–88.
[79] Láng 2011a, 33; Láng 2011b, 30.
[80] Dévai 2011, 134–142.
[81] Haevernick–Hahn-Weinheimer 1955, 65–67.
[82] Foy–Fontaine 2008, 408.
[83] Foy–Fontaine 2008, 408.
[84] Perring 2002, 118.
[85] Foy–Fontaine 2008, 415.
[86] Perring 2002, 118.
[87] Foy–Fontaine 2008, 425–427.

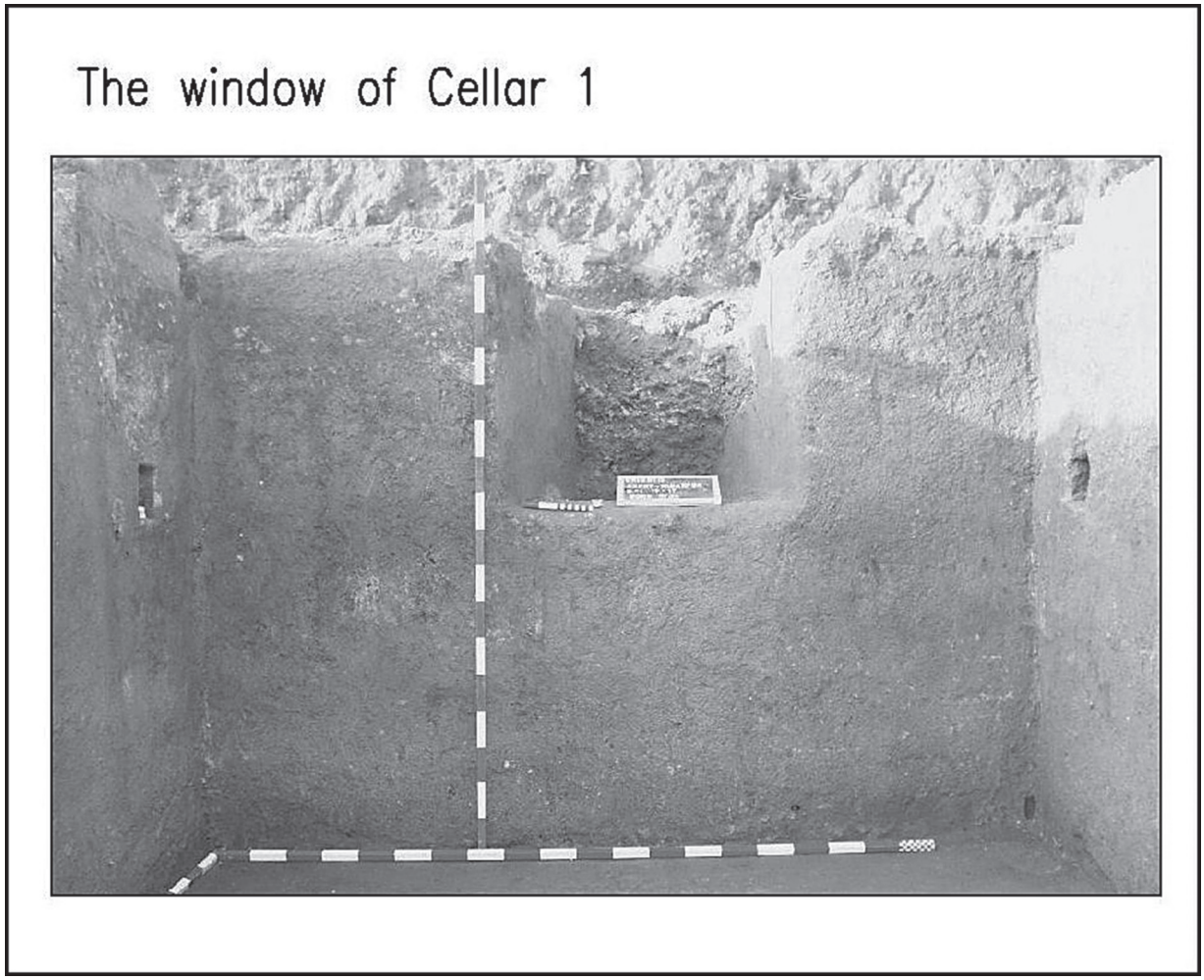


Fig. 9. The remains of a window opening (photo D. Bartus)

probably still working in the 15th century.[88] The *municipium*, however, was supplied with fresh water via wells and cisterns. One cistern and three wells of different age and construction technique have so far been uncovered *(Fig. 10)*.

The earliest well was found under the mortar floor of *Domus* I/b and caused the sinking of the floor over time. It was 0.80 m square and was lined with wood. It must have been built during the 2nd century AD and according to Samian ware finds it was filled when the mortar floor of *Domus* I/b was built at the beginning of the 3rd century AD. Based on the observations of E. Szőnyi these square shaped wood lined wells were usually built during the 1st and 2nd centuries AD in this region.[89]

Another short-lived well was found in *Domus* V, but it was built after the destruction of the house, during the second third of the 3rd century AD. The well was already out of use by the second half of the same century. It had a cylinder-shape with 0.80 m diameter and a depth of at least 4 metres. During the construction process a cylindrical hole of 2.60 m diameter was dug into the ground. When a depth of 2.50–3.00 m was reached, a barrel-like wood construction was lowered into the loose sand. This barrel made the lining of the lowermost part of the well. The mud brick wall of the well was then built up vertically from the bottom. As it is the simplest way of building a hand-dug well, this type of Roman wells was common in Pannonia from the 1st century AD up to the 4th century.[90]

[88] Számadó 1997, 149.
[89] Szőnyi 2003, 143.
[90] Szőnyi 2003, 141–142.

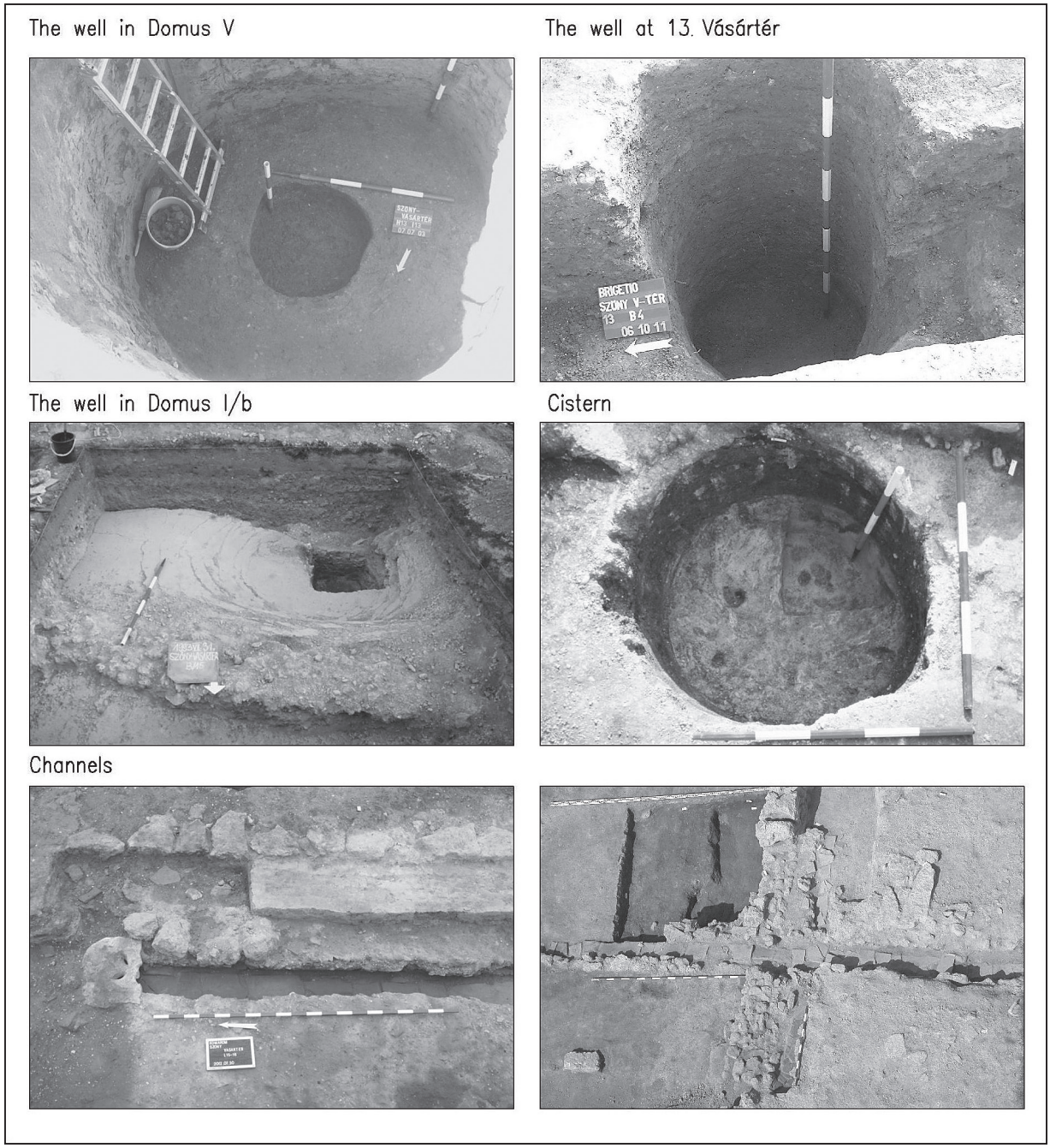


Fig. 10. Wells, a cistern and channels in Brigetio (photos L. Borhy, D. Bartus and Á. Gelencsér)

Another well of the same type was found at 13. Vásártér in *Domus* IV where it served as the well of a glass-making workshop. Located in the backyard of a Roman house, it had a diameter of 0.80 m with an outer ring of 3.10 m. The well was built during the 2nd century AD and was put out of service in the late Severan era.[91]

A cylindrical cistern belonged to the Severan period of *Domus* V. The existing depth of the cistern is not more than 0.60 m with a diameter of 1.25–1.30 m and it was lined with wood. The wood lining was a barrel-like

[91] DÉVAI–GELENCSÉR 2012, 60–63.

construction, for the imprints of the iron hoops were still visible on the wooden staves.[92] The cistern must have been destroyed at the same time as the house around the middle of the 3rd century AD, and – according to the Aurelian (270–275) and Probus (276) coins in the filling – filled up during the 270s when the area was levelled and cleaned.[93]

A network of channels built of rocks and *tegulae* was found in the eastern part of the excavated zone of the *municipium*. These simple, open channels were about 0.30 m wide and were built to carry away rainwater *(Fig. 10)*.[94]

## CONCLUSIONS

The construction techniques observed in the civil town of Brigetio were identical to those in the *canabae* and the legionary fortress – as can be seen from the results of the development-led excavations of the area – and also in the nearby temporary camp of Celamantia near Iža/Leányvár.

The other towns with legionary fortresses in Pannonia: Vindobona, Carnuntum and Aquincum went through similar stages of construction during their lifetime, starting with early timber structures up to adobe or timber-framed walls with stone foundations.[95] In Carnuntum and Aquincum the urbanization process started earlier, they were given the rank of *municipium* at around 124 and the rank of *colonia* around 193 (several decades earlier than Brigetio) and this reflected in the building techniques: in Aquincum for example stone foundations and mortar floors appeared already in the second half of the 2nd century AD. But other than that, Brigetio fits in very well with our general knowledge of the town houses in Pannonia.

The strip houses described as characteristic in Brigetio with stone-founded adobe walls, earth and mortar floors, wall-paintings and hypocaust heating systems seem to be the general house-type in the municipalities of Pannonia from the second half of the 2nd century or the turn of the 2nd and 3rd centuries AD.

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[92] Excavation diary 2001.

[93] BORHY 2005, 80–81.

[94] BORHY *et al.* 2012, 8.

[95] MÜLLER 2008; HUMER 2008; LÁNG 2013; PÓCZY 1970.

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