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PRODUCTION OF CERAMIC BUILDING MATERIAL IN ANCIENT VIMINACIUM

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Abstract. – The technology of brickmaking was introduced to the area of Viminacium by the Romans. The development and growth of the urban settlement in the 1st–4th century necessitated the need for huge quantities of construction materials. Large-scale production of ceramic building materials, which are often abbreviated to CBM, is attested both by the numerous finds of the material itself, as well as traces of the manufacturing process. More than 15 kilns and several structures used in the process were discovered in the vicinity of Viminacium. Still, the subject of Viminacium CBM production has only been modestly studied. Thus, the aim of this paper is to analyse this production, namely the characteristics and organisation of its processes, based on the results of archaeological excavations and previously published research. To achieve this goal, we focused on the layout of the particular manufacturing sites, and the production process organisation, together with the necessary review of the characteristics of the found kilns and other structures used in the production process.

Key words. – Roman CBM production, Viminacium, brick kilns, Pećine, Provalije, Livade nad Ćuprijom, Pirivoj, Kostolac

Ceramic building material (CBM) was unknown to the region of the Middle Danube prior to the arrival of the Romans. In the centuries following the conquest of Illyricum, Viminacium¹ grew to be one of its larger urban settlements (Fig. 01). In the earliest phases of its development, locally available construction materials were preferred,² but from the late 1st – early 2nd century onwards came the widespread usage of CBM. This is attested by the immense quantities of the material, as well as by numerous structures and traces of the production process. Disregarding the smaller finds, more than 15 quadrangular kilns³ and several production structures and features have been unearthed thus far.

In spite of numerous finds, the CBM industries of Viminacium have not been studied from the perspective of all elements of the production process whose traces were recognised at the researched sites. Most kilns came to light during the rescue archaeological excavations, and were published in the form of reports,⁴ while a few attempts were made at analysing its prod-

ucts, considering their epigraphic,⁵ morphological and physical characteristics and later use in buildings⁶. In this paper, we focus on the layout of the manufacturing areas, as well as on the CBM manufacturing process

¹ Regarding the history and development of Viminacium *cf.* Поповић 1968; Mirković 1986, 21–59.

² For the construction materials and techniques applied in the territory of Viminacium, *cf.* Nikolić 2013.

³ The number of quadrangular kilns could be even higher, as Č. Jordović mentions that in the period between 1977 and 1992 a total of 11 brick kilns were excavated on the territory of Viminacium (Јордовић 1994, 96). Three of these could not be verified, as they were not published and we could not find them in the field documentation. Additionally, one recently discovered quadrangular kiln from the site Provalije TEKO – A could not be included in this analysis, as due to its smaller size and the lack of finds, it cannot be associated to CBM production with any degree of certainty.

⁴ Jurišić 1956; Јордовић 1994; Raičković, Redžić 2005; Jovičić, Milovanović 2017; *cf.* Jevtović, Danković 2022.

⁵ Benea 1983; Jevtović 2013.

⁶ Nikolić 2013; Radivojević 2018.

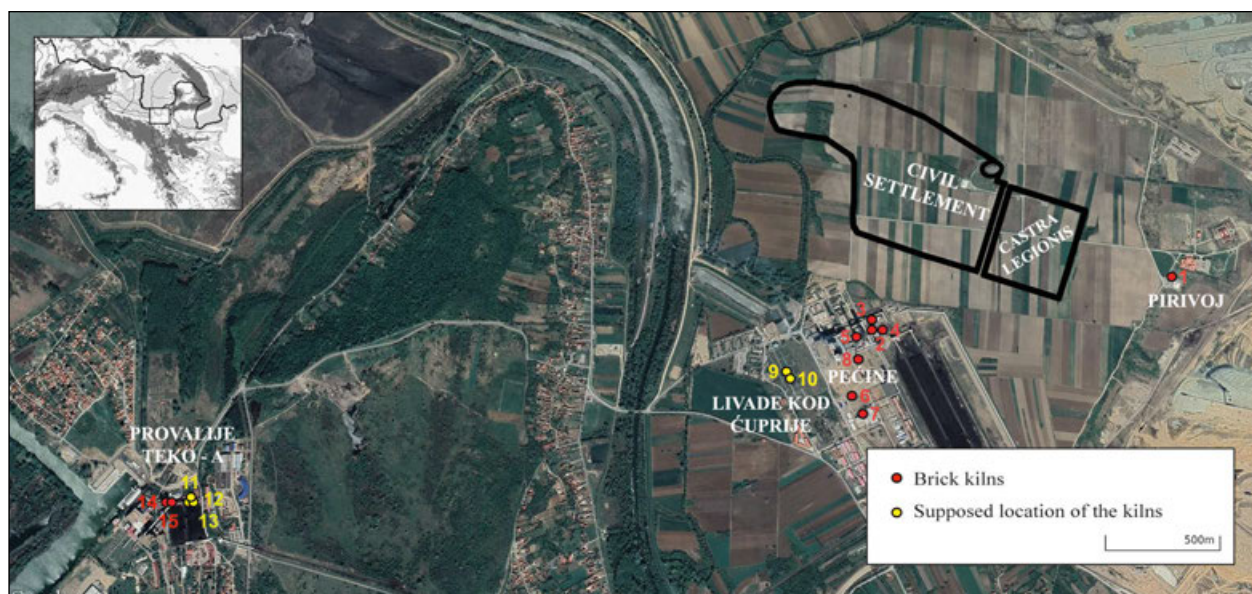


Fig. 1. Plan of Viminacium with the position of kilns (after Jevtović, Danković 2022, 117, Fig. 1)

Сл. 1. План Виминацијума са позицијом њећу (према Јевтović, Danković 2022, 117, Fig. 1)

and organisational aspects of the production. To this end, we will examine the structures, features and finds associated with the manufacture.⁷ The structures and features used in the manufacture of ceramic objects other than CBM (i.e., pottery, lamps, etc.) will not be discussed in detail, although they have to be taken into account since workshops often manufactured various ceramic products.

MANUFACTURING AREAS AND KILNS

Production of CBM and other ceramic finds in Viminacium was located in the same zones, spreading over four manufacturing areas with units, or workshops, located nearby to the east and south of Viminacium city and camp,⁸ at the sites of Pirivoj, Pećine and Livade kod Čuprije in the area of Kostolac village, but also further to the west, at the site of Provalje – TEKO A, situated in the zone of Kostolac town (Fig. 1).

1. Pirivoj

The Pirivoj site is located c. 425 m to the east of the military camp. A single kiln was discovered on the site, on the edge of the eastern necropolis of Viminacium, which was used between the 2nd century and late Antiquity.⁹

Unit 1 (Kiln No. 1)

The kiln (Fig. 2)¹⁰ is positioned some 12 m to the south of the nearest graves, just a few metres from the main road that led from the eastern gate of the camp towards *Pincum* (today Veliko Gradište).¹¹ The immediate surroundings of the kiln were not investigated, but a geophysical survey of the area to the west of the kiln identified several anomalies that could be interpreted as remains of other kilns.¹² The kiln is quadrangular in plan (4.30 x 2.90 m) with one main corridor and six side flues on the same level as the bottom of the main corridor (Fig. 3/1). The kiln operated sometime between the fourth decade of the 3rd century and the third decade of the 4th century. It was emptied after its destruction, while its insides were filled with rubble from its collapsed structure.¹³

⁷ In order to simplify the analysis a new numeration of the kilns from Viminacium will be used. For their detailed description and technical characteristics, as well as for that of other structures and features used in the manufacturing process, one should consult the given literature.

⁸ Jevtović, Danković 2022.

⁹ Cf. Danković et al. 2018 with given literature.

¹⁰ Jovičić, Milovanović 2017.

¹¹ Cf. Danković 2015.

¹² Cf. Jovičić, Milovanović 2017, 31, fig. 12.

¹³ Ibid, 32.



Fig. 2. Kiln No. 1 (Unit 1)
(after: Jovičić, Milovanović 2017, 23, Fig. 4)

Сл. 2. Пећ бр. 1 (Радионица 1)
(према: Јовић, Миловоновић 2017, 23, Fig. 4)

2. Pećine

The site of Pećine is located c. 420 m south of the civil settlement of Viminacium, in the area of the modern-day Kostolac B thermal power plant. It was home to at least four workshops, spread over an area of c. 16,000 m² (Fig. 4). The areas surrounding and between the manufacture units were occupied by the necropolises,¹⁴ which were formed prior to the production complex, during the middle of the 1st century AD and lasted until the middle of the 5th century AD. After the abandonment of production, the workshops were also used as burial grounds.

Unit 2 (Kiln Nos. 2–4)

The workshop named by the researchers the Craftsmen Centre¹⁵ is situated c. 425 m south of the civilian settlement. The workshop comprised three quadrangular kilns, three circular and one small quadrangular kiln, a drying hall(s), a clay pit, a well and remains of several other structures (Fig. 5).

The three quadrangular kilns formed a single structure (“brick-plant”), around a common working space (c. 45 m²) (Figs. 3/2–4, 6). The structure was completely dug in and separated from the surrounding ground by a perimeter wall. Two kilns were next to each other and the third was positioned perpendicularly. These are quadrangular kilns with a single corridor and cross flues at a higher level than the main corridor. It is likely that all three kilns had 6 side flues, but the front part of Kiln No. 3 was damaged, so only 5 were

preserved. The kilns were of similar size, with Kiln No. 4 being the largest (5.05 x 4.00 m), Kiln No. 2 slightly smaller (4.85 x 3.90 m) and the damaged Kiln No. 3 preserved to a lesser extent (3.80* x 4.00 m). The upper chambers of the kilns were filled with large amounts of fragmented bricks, *tegulae* and *imbrices*, which could represent the displaced remains of their load. Several fragmented tiles bore LEGVIICL stamps, while a few were stamped with a LEGVIICLANT stamp. Among this rubble, in Kiln Nos. 3 and 4 were various broken but seemingly complete pottery vessels and a terracotta.¹⁶

To the south and west of the kilns were the remains of eight bases (Fig. 6), made from a combination of bricks and stones with lime mortar.¹⁷ The bases are similar in dimensions, between 0.70 x 0.70 x 0.30 m and 1.00 x 0.90 x 0.25 m. They are spread over an area 32.23 m long and c. 23.80 m wide, unevenly distributed into four unequally long, but parallel rows, c. 7.20–7.50 m apart. The bases in each single row are between 3.90 and 5.45 m apart, and their layout suggests the existence of more bases. They might have been the foundation of a single, or perhaps several porch-like structures (i.e., drying halls), as suggested by their uneven disposition and the position in regard to the quadrangular kilns. The bases carried a wooden construction with a roof made out of *tegulae* and *imbrices*, as indicated by the intensive rubble that covered the area. A well, three smaller circular/oval, and a single small quadrangular kiln were discovered between the bases (Fig. 5). The finds discovered within these kilns testify that they were used for pottery, lamp and terracotta production.¹⁸ To the northwest of the structure, a clay pit was partially excavated (Fig. 5).¹⁹ Its excavated part was c. 9 m long and 5 m wide, with a depth reaching c. 2.4 m. The pit infill contained several concentrations of clay lumps²⁰ and numerous finds. Six smaller waste pits were discovered on the territory of the Craftsmen Centre, filled with broken pottery and terracotta. The remains of two walls and a covered corridor were

¹⁴ Зотовић, Јордовић 1990, 2; Vojvoda, Mrđić 2017, 9.

¹⁵ Јордовић 1994; Raičković 2007.

¹⁶ Ibid.

¹⁷ Јордовић 1994, 101–102.

¹⁸ Ibid, 97–98; Raičković 2007, 14.

¹⁹ Raičković et al. 2006, 69; Documentation of the Institute of Archaeology, Belgrade, unpublished.

²⁰ Documentation of the Institute of Archaeology, Belgrade, unpublished.

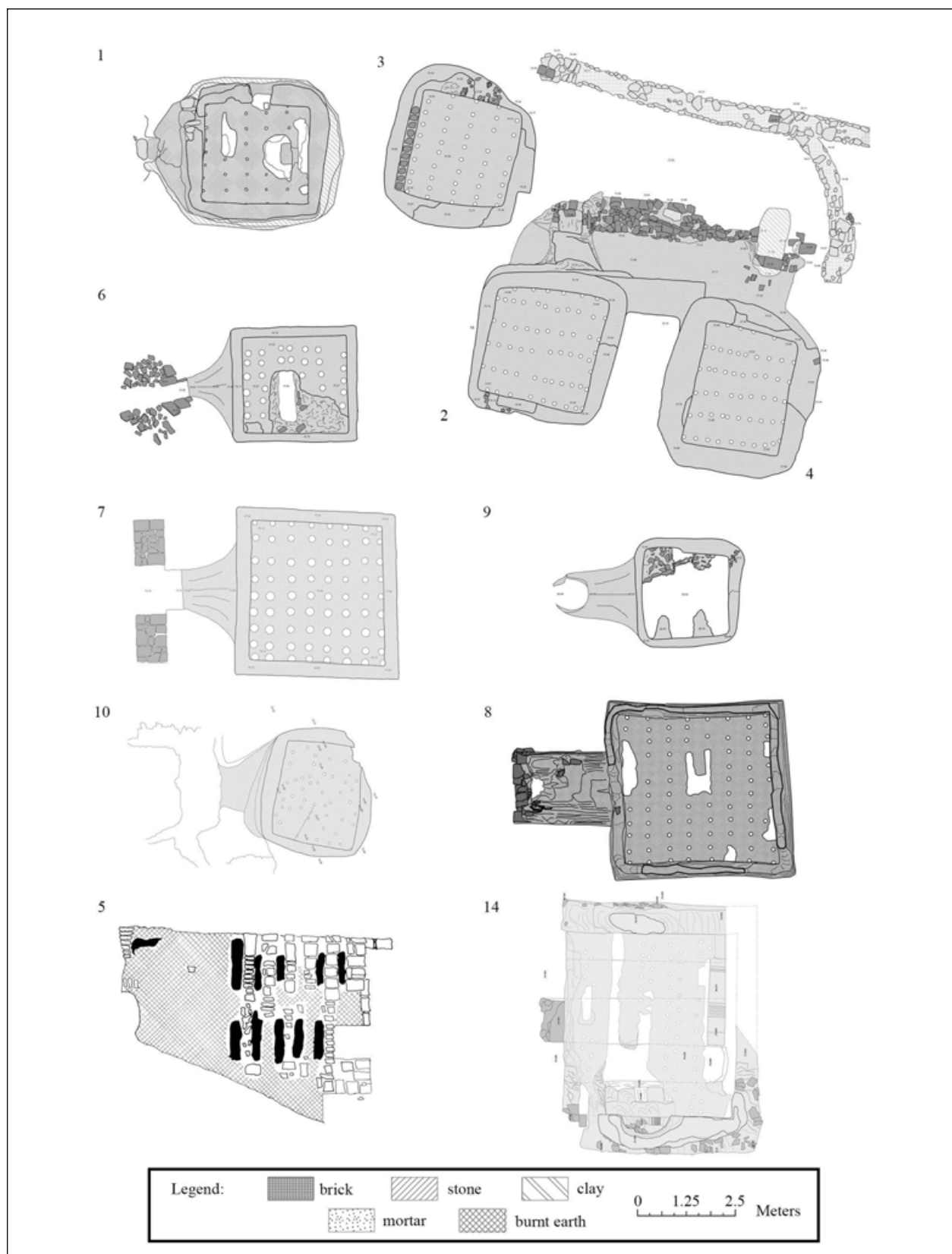


Fig. 3. Kilns of Viminacium (after: Jevtović, Danković 2022, 119, Fig. 2)

Сл. 3. Основе пећи са Виминацијума (према: Jevtović, Danković 2022, 119, Fig. 2)



Fig. 4. Site of Pećine

Сл. 4. Локација Пећине

also discovered on the site, but their position and relationship to the other structures remains unclear.

The pottery analysis,²¹ several coins of Emperor Antonius Pius as well as CBM bearing LEGVIICLANT²² stamps suggests that the CBM production of the Craftsmen Centre occurred during the time of the Severan dynasty. All mentioned structures and features could be a part of the same workshop, as was suggested by the authors,²³ but their layout and differences in the construction technique indicate that at least some of them belonged to different/later phases of its use.

Unit 3 (Kiln No. 5)

The third manufacture unit was excavated c. 50 m to the west of the Craftsmen Centre. It was comprised of a single complex kiln (No. 5),²⁴ with two main corridors and 9 cross flues (Fig. 3/5, 7). It was larger in dimensions (7.30* x 3.80 m) but was heavily damaged, preserved only to the level of the grill. Its combustion

chamber was filled with earth, fragmented CBM and four *tegulae* bearing LEGVIICL stamps. Amongst the rubble, a single coin was discovered, belonging to the mint of the emperor Caracalla. The surroundings of the kiln were devastated prior to the excavation, but in its vicinity, three circular kilns around a common stoke pit were identified.²⁵ The pit had a rectangular shape (2.40 x 1.45 x 2.00 m) and was filled with pottery shards and tile fragments, which suggest that it also served as a waste pit. The precise position and the relationship of all the mentioned features and structures remains uncertain.

²¹ Raičković 2007, 74.

²² Јордовић 1994, 101; Mirković 1977; Kurzmann 2005, 328–329; Warry 2006, 58.

²³ Jordović 1994, 105; Raičković 2007, 50.

²⁴ Raičković, Redžić 2005, 85–86.

²⁵ Ibid, 82–84; Raičković 2007, 13, 18.

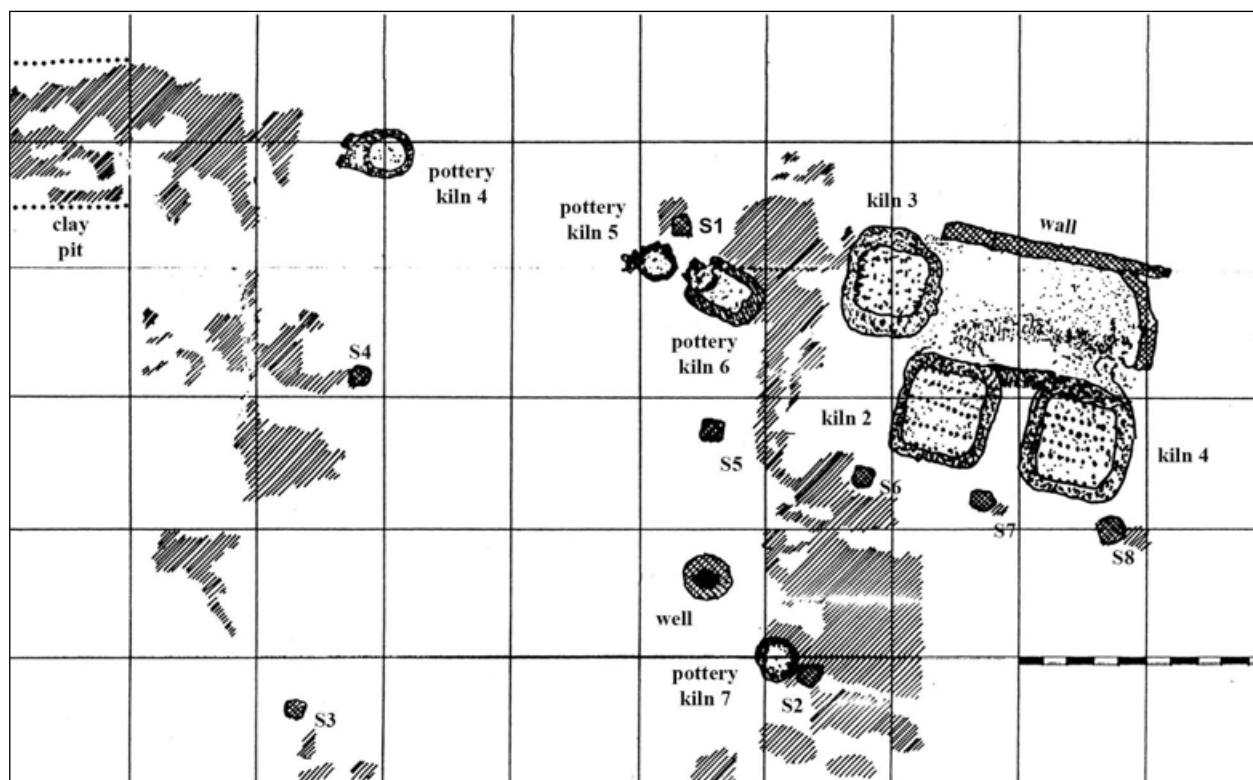


Fig. 5. Unit 2 – “Craftsmen Centre” (Documentation of the Institute of Archaeology, Belgrade)

Сл. 5. Радионица 2 – „Занайски центар” (Док. Археолошкој институцији, Београд)

Based on the mentioned finds, Kiln No. 5 was operational sometime after the reign of Emperor Hadrian,²⁶ most likely in the latter half of the 2nd century, and was abandoned prior to the early 3rd century.

Unit 4 (Kiln Nos. 6 and 7)

The unit is located in the southern part of the Pećine site, some 315 m southwest of the Craftsmen Centre. It was comprised of two kilns (No. 6²⁷ and 7²⁸) 18 m apart, placed on the edges of a large borrow pit.²⁹ Both kilns are simple quadrangular kilns with a single main corridor and four cross flues positioned higher than the bottom of the main corridor (Fig. 3/6–7). Kiln No. 6 (Fig. 8) is smaller (4.30 x 2.95 m) and Kiln No. 7 (Fig. 9) is larger (5.50 x 4.00 m). The collapse of the grill of Kiln No. 6 caused its load of *imbrices* to fall into the combustion chamber. Additionally, piles of wasters were discovered on both sides of its *praefurnium*. Among these, two fragments were marked with a LEGVIICL stamp.³⁰ Kiln No. 7 had no traces of damage and was emptied after its destruction. A single stamped brick was discovered in front of the kiln, on the edge of

the clay pit. The researchers originally identified the stamp as LEGVIICLPF,³¹ but a re-examination determined that it reads LEGVIICLPS, which dates it to the late 3rd – early 4th century.³²

The borrow pit had an irregular shape, c. 40 x 32 m in dimensions (c. 1,280 m²) and was more than 4 m deep at certain points (Fig. 10). Several piles of clay lumps and stacks of finished CBM were discovered on its bottom (Fig. 11). Its edge in front of Kiln No. 7 was covered with waste from the firing of the kiln (mainly ash). After the abandonment of the workshop, the pit was filled with 2nd–4th century material, originating

²⁶ Cf. Jevtović 2013, 41–43.

²⁷ Raičković, Redžić 2005, 85, 91, 93, P. I, III.

²⁸ Ibid, 84, 91, 96, 106, Sl. 2, 4; P. I, VI; Redžić et al. 2018a, 87–88.

²⁹ Redžić et al. 2018a, 87–88.

³⁰ Documentation of the Institute of Archaeology, Belgrade, unpublished.

³¹ Redžić et al. 2018a, 88.

³² Jevtović 2013, 46; cf. Dušanić 1978.



Fig. 6. Kiln Nos. 2–4 (Unit 2) (after Nikolić 2013, 28, Fig. 12)

Сл. 6. Пећи бр. 2–4 (Рагионица 2) (према: Nikolić 2013, 28, Fig. 12)

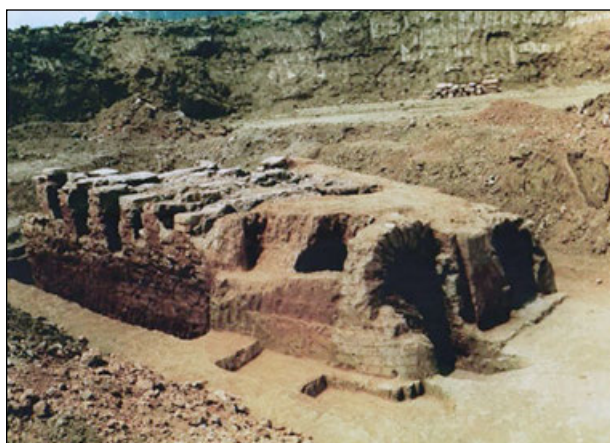


Fig. 7. Kiln No. 5 (Unit 3) (after: Mirković 2007, 79, Abb. 72)

Fig. 8. Kiln No. 6 (Unit 4) (Documentation of the Institute of Archaeology, Belgrade)

Сл. 7. Пећ бр. 5 (Рагионица 3) (према: Mirković 2007, 79, Abb. 72)

Сл. 8. Пећ бр. 6 (Рагионица 4) (Док. Археолошкој инстџиуиуи, Београд)





Fig. 9. Kiln No. 7 (Unit 4) (after: Raičković, Redžić 2005, 106, Sl. 4)

Fig. 10. Unit 4, The edge of the clay pit in front of Kiln No. 7 (Documentation of the Institute of Archaeology, Belgrade)

Сл. 9. Пећ бр. 7 (Радионица 4) (према: Раиčković, Redžić 2005, 106, Сл. 4)

Сл. 10. Радионица 4, Обод јаме-глиништа испред пећи бр. 7 (Док. Археолошкој институцији, Београд)

from the cleaning of the necropolis. Some c. 10 m to the south of the kilns and the pit lie the remains of a large, solid wall building, traces of some wooden structures and a well.³³ The precise function and the chronology of these structures cannot be determined, so at the moment they cannot be linked to the CBM production.

The workshop operated sometime in the period between the reign of Emperor Hadrian and the middle of the 3rd century. This dating is based on the two mentioned fragmented bricks with a LEGVIICL stamp,³⁴ which can be unequivocally associated with the output of Kiln No. 6.³⁵

Unit 5 (Kiln No. 8)

The unit is located in the central area of the Pećine site, some 70 m southwest of the Craftsmen Centre. It

was comprised of a kiln and a clay pit.³⁶ Kiln No. 8 is a simple quadrangular kiln with a single corridor and six cross flues positioned higher than the level of the central corridor (Figs. 3/8, 12). It is large (6.76 x 4.60 m) and preserved to a great extent, with the oven walls preserved to a maximum height of 1.25 m. Due to the damage to the oven floor, its lower parts were filled

³³ Documentation of the Institute of Archaeology, Belgrade, unpublished.

³⁴ Cf. Jevtović 2013, 41–43.

³⁵ It is our opinion that the third stamped brick, the one discovered in the pit in front of Kiln No. 7, has to be excluded from the chronological analysis. This is mainly due to its ambiguity and its arguable attribution to the kiln (the pit was backfilled with various materials after the abandonment of the workshop).

³⁶ Redžić et al. 2018b; Redžić et al. *in prep.*



Fig. 11. Stacks of CBM in the clay pit of Unit 4 (after: Jevtović, Danković 2022, 121, Fig. 4)

Fig. 12. Kiln No. 8 (Unit 5) (Documentation of the Institute of Archaeology, Belgrade)

Fig. 13. Clay pit of Unit 5 (Documentation of the Institute of Archaeology, Belgrade)

Сл. 11. Наслајане ојке у јами-глинишћу радионице 4 (према: Јевтoвић, Дaнкoвић 2022, 121, Fig. 4)

Сл. 12. Пећ бр. 8 (Радионица 5) (Док. Археолошкој инстџићуића, Београ)

Сл. 13. Јама-глинишће радионице 5 (Док. Археолошкој инстџићуића, Београ)

with lumps of burnt earth mixed with soil, parts of the kiln's construction, fragmented pottery, animal and human bones, whole and fragmented CBM, a single coin of Emperor Hadrian and a hinged strap of a *lorica segmentata* of the Corbridge type. Amongst the CBM from the filling and the construction of the kiln, a total of 168 pieces bear LEGVIICL stamps of different types.³⁷

The pit is located c. 20 m to the south of the kiln. It had an irregular shape (105* x 58* m) and its edges were only partially defined (Fig. 13). It was c. 3 m deep. The material from its infill indicates that it was filled sometime after the second half of the 2nd century, most likely in the 3rd and/or 4th century.³⁸

The stamped CBM, other mentioned finds and the filling of the pit indicate that the Unit 5 functioned in the middle – second half of the 2nd century.³⁹

3. Livade kod Ćuprije

The site is located some c. 200–250 m west of the larger production centre on the site of Pećine. A 4th century *villa rustica* was discovered on the site,⁴⁰ but data pertaining to the site is scarce, as the results were only partially published.

Unit 6 (Kiln Nos. 9 and 10)

Fragmentary information is available on the two kilns (No. 9 and 10) discovered on the site. Their precise location and relationship, both mutual and with

³⁷ Ibid.

³⁸ Ibid.

³⁹ Ibid.

⁴⁰ Jovičić, Redžić 2012.



Fig. 14. One of the kilns No. 11–13 (after: *Ненадовић, Јуришић 1956, 129, Sl. 11*)

Fig. 15. Kiln Nos. 14 and 15 (after: *Jevtović, Danković 2022, 122, Fig. 5*)

Сл. 14. Једна од пећи бр. 11–13 (према: *Ненадовић, Јуришић 1956, 129, Сл. 11*)

Сл. 15. Пећи бр. 14 и 15 (према: *Jevtović, Danković 2022, 122, Fig. 5*)

the other structures, are unknown, except for the fact that they were not in the immediate vicinity of one another. Both kilns are common kilns with a central corridor (Fig. 3/9–10).

Kiln No. 9 was larger (4.80 x 2.75 m) and had three side flues. The only available data regarding Kiln No. 10 had to be extracted from its plan. It was only partially preserved (3.85* x 3.25 m). No details are known about the finds discovered in the kilns. Regarding their relationship with the 4th century villa and other structures on the site, they are dated in the 2nd–3rd century.⁴¹ A well, several dumping pits and at least five circular kilns were also excavated on the site.⁴² It seems that only one of these round kilns predates the villa and should be dated in the 2nd or 3rd century,⁴³ while the rest seem to date to the medieval period. Their precise position and details regarding other features are unknown, but one feature stands out. According to the authors,⁴⁴ one circular pit originally served as a well, or for the storage of clay, while in the later phases of the production, or after its abandonment, it served as a dumping pit.

4. Provalije – TEKO A

The site of Provalije is located some 3.30 km west of the civilian settlement, on the opposite bank of the Mlava river, in the territory of the modern-day Kostolac A thermal power plant. Nine brick and pottery kilns were discovered and subsequently destroyed in 1942 – 1944, during the construction of the power plant.⁴⁵

Unfortunately, no further data is available on these structures. Since then, six kilns⁴⁶ have been identified and partially explored on the site.

Unit 7 (Kiln Nos. 11–13)

Most details regarding Kiln Nos. 11–13 are unknown,⁴⁷ including their precise position and ground plan (Fig. 14). The kilns were 28 and 11 m apart and perhaps formed a single battery with a common working space (c. 154 m²). All three were simple quadrangular kilns with a single corridor and a completely dug in lower chamber. Two (Nos. 11–12) were of smaller size (3.10 x 3.50 m; 2.60 x 2.70 m), while the third (No. 13) was mostly destroyed. One of the kilns had the upper chamber filled with fragmented CBM, while the other two were emptied prior to their abandonment.⁴⁸

⁴¹ Ibid, 372.

⁴² Ibid; Raičković, Redžić 2005, 82; Documentation of the Institute of Archaeology, Belgrade, unpublished.

⁴³ Jovičić, Redžić 2012, 372; Documentation of the Institute of Archaeology, Belgrade, unpublished.

⁴⁴ Raičković, Redžić 2005, 87.

⁴⁵ Orlov 1960, 314.

⁴⁶ Remains of another quadrangular kiln were discovered in 2019, but at the moment it cannot be associated with CBM production.

⁴⁷ Јуришић 1956, 129–130.

⁴⁸ Ibid.

Unit 8 (Kiln Nos. 14 and 15)

Kiln No. 14 was discovered during small-scale rescue excavations, during which the outer shell of Kiln No. 15 was also identified (Figs. 3/14, 15).⁴⁹ The kilns are positioned next to each other and most likely formed a single production unit. Kiln No. 14 is a complex kiln with two main corridors (Fig. 15). It is a large kiln (5.40* x 5.80 m), with the area of the combustion chamber covering c. 19.32* m². The combustion chamber was filled with numerous broken bricks and tiles, as well as several green ones. A single *tegula* with a LEGIII stamp and four marked with the uncharacteristic stamp LEGVIIICLATILIVIM were discovered in the upper chamber.⁵⁰

More numerous finds of stamped CBM of the *Legio VII Claudia* indicate that the unit functioned sometime between the rule of Emperor Hadrian and the middle of the 3rd century.⁵¹ The presence of CBM of the *legio IV Flavia* could indicate that production started in an earlier period (late 1st – early 2nd century),⁵² but this cannot be stated categorically without further evidence.

ELEMENTS OF THE PRODUCTION PROCESS

As evidenced, CBM production at Viminacium was a vast and complex enterprise. In order to better understand it, further examination of the structures is needed from the perspective of the production process. Traditionally, this process can be divided into several stages,⁵³ which include procurement of the raw materials, their treatment – weathering, soaking and refinement, later shaping into products, their drying, firing and storage. Each phase had its own requirements and left its own material remains in the form of structures, artefacts, or different traces in the ground. Still, one has to bear in mind that it was not necessarily a uniform process and that many operations left no material impression and are, thus, undetectable.

Raw materials and their procurement

Clay with the right characteristics,⁵⁴ neither too “lean” nor too “greasy”, was primarily extracted from large open pits. Preferably, the source material contained a mixture of clay, sand and silt, where each element contributed some necessary quality to the final product.⁵⁵ The region of Viminacium is known for good quality clay⁵⁶ and several extraction areas were

identified on its territory, to the east,⁵⁷ north⁵⁸ and south⁵⁹ of the settlement and the camp. Except for the pits on the site of Pećine,⁶⁰ currently these cannot be associated with CBM production. The pits that served Units 2, 4 and 5 are large in volume – c. 45* m², 1,280 m² and 6,000* m² respectively,⁶¹ which testifies to the longevity of their use and the volume of production. They were located in close proximity to the kilns, positioned in a way that best facilitated the manufacture process. The area between the kilns and the pit of Unit 2 was used for the manufacturing of products and we can state that a similar arrangement characterised Unit 5. Unit 4 exemplifies a different arrangement, as the kilns were positioned on the edge of the pit. The pits served multiple functions, as there is evidence that they were used for the preparation of the raw material and for storage of products, but it seems less likely that they also served as a workshop. The sources of clay for the production on the other sites remain unknown, but we can assume that they were located in the vicinity of the workshops.

The second essential element for CBM manufacture is water. It could be drawn from natural sources by water conducting and gathering systems (ditches,

⁴⁹ Jevtović, Danković 2017; Jevtović, Danković 2022, 122.

⁵⁰ Ibid.

⁵¹ Jevtović 2013, 45–46.

⁵² Various epigraphic evidence places the presence of the legion at Viminacium in the period of the late 1st – the early 2nd century and also sometime during the 3rd century (cf. Поповић 1968, 36–37; Mirković 1975, 907–908; Mirković 1986, 37–38; Ферјанчић 2002, 159–160).

⁵³ McWhirr 1984, 50, fig. 49a; Maggetti 2001, 924; Fernandes et al. 2010, 30–31; Radivojević 2018, 81–82, fig. 36.

⁵⁴ Cf. Pliny *Nat.* XXXV.49.169–173; Vitruvius *Arch.* II.3.1–3; II.8.16–17.

⁵⁵ Cf. Rice 1987, 118–119; Wright 2005, 78; Quinn 2013, 154; Radivojević 2018, 81–82.

⁵⁶ Jeremić 2001, 151–152; Jordović 1994, 96; Marrese et al. 2015, 13–14, fig. 4a, 16–17; Osnovna geološka karta SFRJ, list Bela Crkva, L 34–115.

⁵⁷ Cf. Raičković, Milovanović 2010; Vuković 2010.

⁵⁸ Danković, Petaković 2014, 61.

⁵⁹ Валтровић 1884, 98–99; Mrđić 2009, 65, 164, 166.

⁶⁰ Another large clay pit (55* x 19.6* m) was partially discovered during recent research of the northern part of the site, but at the moment it cannot be linked to the CBM production (cf. Redžić et al. 2021, 118–119).

⁶¹ Area wise, the closest analogy is the pit from Varbovski livadi (Pavlikeni, Bulgaria), which is significantly smaller, covering an area of 500 m² (Sultov 1985, 22).

⁶² Humphrey 2006, 36–38; Peacock 1982, 54; Swan 1984, 6.

aqueducts, pipes, or cisterns/reservoirs) or from wells.⁶² The area of Viminacium is characterised by relatively high groundwater levels, due to the proximity of the Danube and Mlava rivers and the soil composition. For this reason, it seems that wells were a preferable choice,⁶³ as indicated by the finds from the sites of the Craftsmen Centre⁶⁴ and the site of Livade kod Čuprije⁶⁵. Additionally, it is believed that the production on the site Pirivoj was also supplied by a single or several wells.⁶⁶

An often overlooked material used in the manufacturing of CBM was sand. It could be gathered by the mining of the geological layers in the open pits, or by utilising river beds. At this moment, the source of sand for CBM production of Viminacium cannot be determined.⁶⁷ There are some indications that geological layers discovered during the excavation of clay could have been used, but it is doubtful if these could have supplied adequate quantities of the material.

The last raw material requirement in the manufacturing process was fuel. No direct evidence for the type of fuel used in the manufactories of Viminacium has been discovered. It was probably some sort of biomass fuel, most probably wood and cereal chaff, but charcoal, coal or dung could also have been used.⁶⁸ Regardless of the material, large quantities were needed for firing each kiln⁶⁹ and it was obtained locally, as the woodlands, agricultural fields and marshy areas of Stig provided ample material.⁷⁰

The treatment of raw materials and preparation of the final products

The second phase of production involved the treatment of raw materials for their final mixing and shaping into bricks and tiles. It included the stockpiling of raw clay in an open-air storage area, such as paved areas, basins, tanks, or pits, where it could be left to weather, crushed and ground, soaked, purified and enriched or thinned.⁷¹ The only structures that were identified as such are the circular pits discovered on the site of Livade kod Čuprije, although the authors⁷² do not provide any details that could substantiate such an interpretation. Six pits from the Craftsmen Centre (Unit 2) and, even more likely, the rectangular pit from the vicinity of Unit 3 could have served the same purpose,⁷³ prior to their use for waste disposal. Unfortunately, none of these features can be directly associated with CBM production. The only concrete trace of this process was piles of clay lumps, discovered in the clay pits of Units 2 and 4. The lumps testify that the

initial purification was performed during the excavation of the clay, but as the pit was used as a working area, it does not seem implausible to conclude that a section of the pit was designated for the preparation of the raw materials.

Further refinement, moulding and drying⁷⁴ of products was usually done in the open or, in the case of large-scale and more organised production, in special buildings of various complexity. These ranged from simple shelters, sheds or huts, to a single solid building that could even incorporate the kiln. The only remains identified as such structure(s) were found in the Craftsmen Centre (Unit 2), where single or multiple structures covered an area of c. 600 m². Analogous, porch-like, multi-aisled structures, interpreted as drying halls, were identified throughout the Empire, mostly in military production centres,⁷⁵ but also in privately owned workshops⁷⁶. They vary in size and compared to Unit 2 structure(s), they can be smaller, as with the one in Vindobona (c. 182 m²),⁷⁷ or significantly larger, such as those in Hunzenschwil–Vindonissa⁷⁸ (>990 m²) or Xanten,⁷⁹ which was c. 60 m long. In other workshops of Viminacium moulding and drying was at least partially done in the open, as plenty of CBM carries impressions of paws, hoofs or claws.⁸⁰ Yet, as the drying was severely conditioned by climatic conditions,⁸¹ the

⁶³ Danković, Bogdanović 2017.

⁶⁴ Јордовић 1994, 101.

⁶⁵ Raičković, Redžić 2005, 87.

⁶⁶ Jovičić, Milovanović 2017, 32.

⁶⁷ The only trace of sand mining at Viminacium is a sandpit in the site of Rit, which at the moment cannot be associated with the ceramic production (Danković, Petaković 2014, 63).

⁶⁸ McWhirr 1979, 100; Orton, Hughes 2013, 123–124; Rice 1987, 118–119; Rowan 2015, 465; Swan 1984, 6–7.

⁶⁹ Cf. Mayes 1962; Peacock 1982, 25; Brandl, Federhofer 2010, 36.

⁷⁰ Јордовић 1994, 96.

⁷¹ Adam 2005, 111; Radivojević 2018, 83.

⁷² Raičković, Redžić 2005, 87.

⁷³ A similar tank/basin/pit was discovered in the pottery workshop of Marcus Perennius in Arezzo (Cuomo di Caprio 2007, 150).

⁷⁴ Cf. McWhirr 1984, 101–102.

⁷⁵ Cf. Mosser 2015, 67, footnote 39; Deschler–Erb 2012, 41, footnote 82 with given literature.

⁷⁶ Aubert 1994, 206; Ventura, Cividini 2011, 9.

⁷⁷ Mosser 2015, 67.

⁷⁸ Schaer 2005, 48 f. Figs. 10 and 11; Deschler–Erb 2012, 44.

⁷⁹ According to Mosser 2015, 67.

⁸⁰ Jevtović *in prep.*

⁸¹ Fernandes et al. 2010, 3.

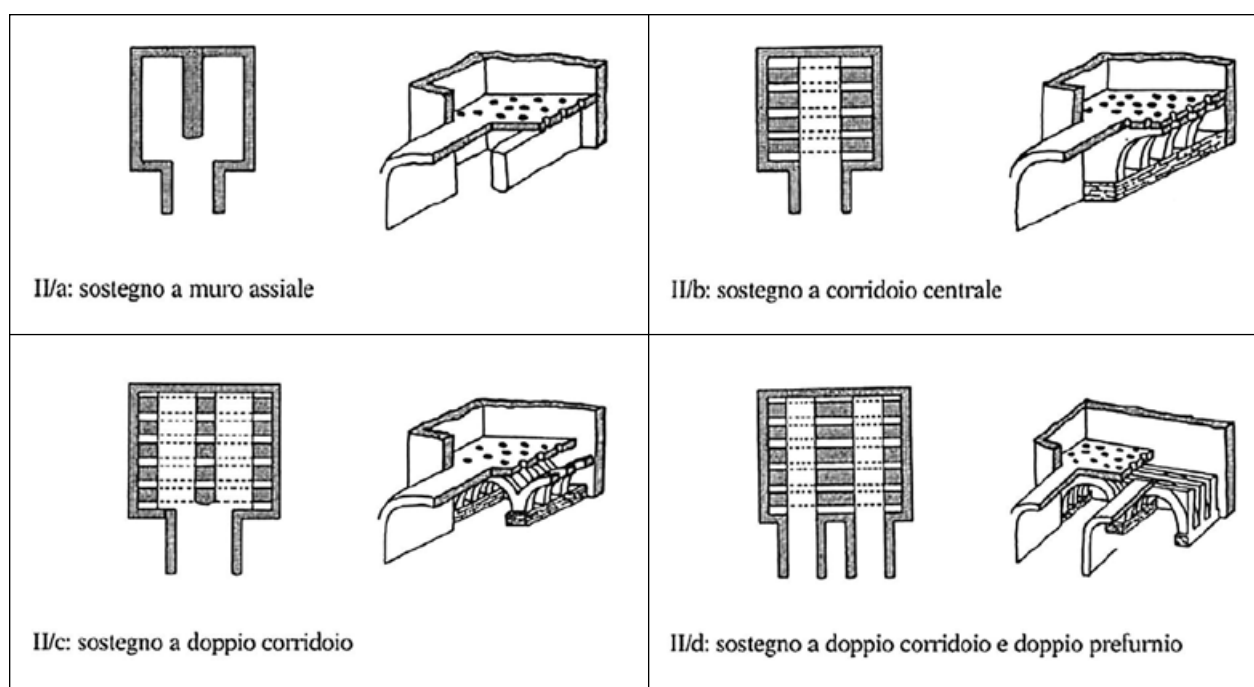


Fig. 16. Typology of kilns based on the plan of the lower part of the kiln and the type of support for the upper structure (after: Cuomo di Caprio 2007, 524, Fig. 169)

Сл. 16. Типологија пећи према основи доње коморе и изгледу носача решетке (према: Cuomo di Caprio 2007, 524, Fig. 169)

material had to be protected, either by covering it with straw or sand,⁸² or by use of simple shelters or porches.

Firing

The final stage of the manufacturing process was the firing.⁸³ All the kilns used for firing CBM on the territory of Viminacium were quadrangular two-chambered kilns with a vertical draught, typical of the Roman Empire.⁸⁴ For the purpose of this paper, we will use the standard classification, developed by N. Cuomo di Caprio (1978/1979), based upon the plan of the lower part of the kiln and the type of support for the upper structure (Fig. 16). Two types of these kilns are identified among 14 kilns found at Viminacium, while one kiln (Kiln No. 15) cannot be associated to any type (Table 1).

Quadrangular kilns with a single corridor (type II/b)

The majority of kilns (No. 1–4, 6–10) belong to the simpler type of quadrangular kilns with a single corridor (type II/b). It is one of the most common types of quadrangular kilns in the Empire and the

most common type on the territory of Moesia and the surrounding provinces. Five kilns of this type were discovered on the territory of Moesia Superior,⁸⁵ eleven in Pannonia Inferior,⁸⁶ twelve on the territory of Dalmatia⁸⁷ and fifteen on the territory of modern-day Bulgaria⁸⁸. The kilns from the site of Provalije (No. 11–13) probably also belong to this type. However, they can also be identified as type II/a – a quadrangular kiln with a central wall, even though none of the quadrangular kilns from Viminacium belong to this type.

⁸² Cf. Nolla et al. 1982, 152–156.

⁸³ Cf. McWhirr 1984, 103; Cuomo di Caprio 1972, 442.

⁸⁴ Le Ny 1988, 19–29.

⁸⁵ Марић 1951, 121–123; Бућић, Петровић 1984, 8; Љамић–Валовић 1985; Минић 1990.

⁸⁶ Dimitrijević 1969, 108; Jeremić 2000; Vámos 2010, 68; Dobosi 2021.

⁸⁷ D'Inca et al. 2010, 315–318; Kovačić et al. 2011, 519–521; Lipovac Vrkljan, Šiljeg 2012, 22–28; Lipovac Vrkljan 2016, 41–52; Silajdžić 2018, 234–235.

⁸⁸ Харизанов 2019, 358–359, Table 2.4.

KILN No.	SITE-UNIT	TYPE	KILN PLAN DIMENSIONS (m)	KILN HEIGHT (m)	CROSS FLUES (No.)	GRILL THICKNESS (m)	OVEN PLAN DIMENSIONS (m)	PRESERVED OVEN HEIGHT (m)	PRAEFURNIUM PLAN DIMENSIONS (m)
1	Pirivoj - Unit 1	II/b	4.30 x 2.90	2.30	6	0.15	2.70 x 2.50	0.70	1.05 x 0.90
2	Pećine - Unit 2	II/b	4.85 x 3.90	3.10	6	0.37	3.10 x 2.80	1.60	1.30 x 1.00
3	Pećine - Unit 2	II/b	3.80* x 4.00	3.35	5*	0.47	2.60 x 2.75	1.66	0.90* x 0.80
4	Pećine - Unit 2	II/b	5.05 x 4.00	3.50	6	/	3.30 x 2.80	1.60	0.75* x 1.10
5	Pećine - Unit 3	II/d	7.30* x 3.80	1.95	9	/	/	/	/
6	Pećine - Unit 4	II/b	4.30 x 2.95	2.85	4	0.40	2.70 x 2.55	1.10	1.00 x 0.90
7	Pećine - Unit 4	II/b	5.50 x 4.00	> 3.00	4	0.45-0.60?	3.40 x 3.55	1.00	1.30 x 1.00
8	Pećine - Unit 5	II/b	6.76 x 4.60	3.30	6	0.23	4.00 x 3.85	1.25	2.15 x 1.80
9	Livade kod Ćuprije - Unit 6	II/b	4.80 x 2.75	1.60	3	/	2.20 x 2.15	0.40	0.85 x 0.80
10	Livade kod Ćuprije - Unit 6	II/b	3.85* x 3.25	1.80	/	/	2.10 x 2.60	0.50	/
11	Provalije - Unit 7	II/a-b	3.10 x 3.50	/	/	/	/	/	/
12	Provalije - Unit 7	II/a-b	2.60 x 2.70	/	/	/	/	/	/
13	Provalije - Unit 7	II/a-b	/	/	/	/	/	/	/
14	Provalije - Unit 8	II/d	5,40* x 5,80	3.55	6*	/	4.20* x 4.60	1.60	/
15	Provalije - Unit 8	/	/	/	/	/	/	/	/

Table 1. Characteristics and dimensions of CBM kilns of Viminacium

Табела 1. Карактеристике и димензије ојкарских пећи са Виминацијума

The kilns of this type from Viminacium range in size between 2.60 x 2.70 m (No. 12) and 6.76 x 4.60 m (No. 8) (Table 1).⁸⁹ Generally, most of the kilns from Viminacium (No. 1–4, 6–8) have an oven area greater than 6.50 m², which can be considered a larger variant. The remaining four kilns (Nos. 9–12) have an oven area smaller than 5.50 m². Compared to the other kilns from Moesia and the surrounding provinces, kilns from Viminacium fall into the larger part of the spectrum.

Construction-wise, all kilns from Viminacium are similar in plan and construction materials, but each slightly differs in details of their construction techniques. The materials used in the construction, fired brick and tiles, adobe, mud, clay and daub, were commonplace throughout the Empire. Thus, no chronological, regional or even local characteristics could be detected in the case of these kilns. The only significant difference was the use of true arches instead of corbelled ones,⁹⁰ as opposed to all of the kilns from Moesia, except for the one at Margum (today Dubravica)⁹¹.

Quadrilateral kilns with two corridors (type II/d)

Two kilns (Nos. 5 and 14) belong to the more complex type of quadrilateral kilns with two corridors (type II/d). Both were damaged, but, based on the preserved parts, their oven area was larger than 20 m², which is almost double the capacity of the previously discussed type (Table 1). This type of kiln was rare, but was present throughout the Empire, even though its construction elements varied drastically. Considering the vicinity of Viminacium and the neighbouring provinces, two kilns each were discovered on the ter-

⁸⁹ The dimensions of Kilns Nos. 13 and 15 are not known, although Kiln No. 13 most likely falls into the lower part of the spectrum and Kiln No. 15 into the larger.

⁹⁰ Unfortunately, we do not know if the Kilns Nos. 9–13 and 15 had true or corbelled arches.

⁹¹ Марић 1951, 121–123.

ritories of Mosia Superior,⁹² Moesia Inferior⁹³ and Pannonia Inferior⁹⁴, while one was excavated in Dalmatia⁹⁵ and one in Dacia⁹⁶. Kilns of this type were usually large, but could also be small, such as Kiln No. 2 from Sirmium⁹⁷, whose internal dimensions are 3.20 x 2.20 m, or the one from Romula,⁹⁸ which is slightly larger – 4.12 x 3.75 m.

Although both kilns fall into the same type, and standard materials were used in their construction, they are significantly different. To name just the major differences compared to their standard features – Kiln No. 14 had arches made out of two courses of bricks instead of one, while Kiln No. 5 had no back wall.

Specialisation of production

Our research points to the conclusion that in Viminacium, CBM was made exclusively in quadrangular kilns of the mentioned types. Still, numerous discoveries have shown that the shape of the kiln is not a deterministic factor in regards to the product.⁹⁹ The mixed loads of Kilns Nos. 3 and 4 (CBM, pottery and terracotta) suggest that their load was occasionally supplemented by a variety of other ceramic material. This phenomenon does not link to the size and complexity of the kilns, but rather to the size, organisation and production repertoire of the workshops. Larger and more organised workshops often had both circular and quadrangular kilns and simultaneously produced various types of ceramic material. It was economical and practical to make use of the occasional free space in the quadrangular kilns to supplement the production of smaller objects. Based on the current evidence, it is possible that at least one of the circular kilns discovered in the workshop of Livade kod Čuprije (Unit 6) and some from Unit 2 (i.e., the Craftsmen Centre) could have operated simultaneously with the CBM manufactories.

Housing, storage and waste disposal

No support facilities were identified in the territory of Viminacium, neither for the accommodation of workers nor for the storage of tools,¹⁰⁰ materials or products. It seems likely that the vicinity of the camp and the settlement negated the need for housing and storage infrastructure at the sites of Pirivoj, Pećine and Livade kod Čuprije. Some may have existed in the site of Provalije – TEK O A, but the site has only been moderately excavated. Finished CBM products were probably stored in the open, which is exemplified by the stacks of bricks from the pit of Unit 4 (Fig. 11).

The production process created a lot of waste in the form of debris from the firing of the kilns, as well as wasters. However, only a comparatively few waste pits could be identified. The clay pit on the site of Pećine served as a dumping area during the firing of the kilns, and a few smaller pits were identified in the more thoroughly excavated sites of Pećine and Livade kod Čuprije. These pits could have been used in the beginning phases of the production process as a source of raw material and only later used for the disposal of wasters and other leftovers from the production process.

DISCUSSION ON THE MODES OF PRODUCTION

Archaeological research of the CBM industries of Viminacium has identified four production areas, and our study allows us to divide them into two groups, considering two distinct modes of production, where each would have been characterised by its own organisation, structures and requirements.

Large scale production (Units 2–5 and 7–8)

Large scale production was identified at the sites of Pećine and Provalije – TEK O A. Each production area comprised of several workshops (i.e., production units), which were operated by the *Legio VII Claudia*¹⁰¹ and the latter perhaps in cooperation with the *Legio III Flavia*.¹⁰² Judging by the layout of Units 2 and 4, the production was characterised by a high degree of

⁹² Caričin Grad and on the site Crnoklište – Gornje polje (SO Pirot).

⁹³ Атанасов, Ганчева 2019, 359–361; Атанасов et al. *in press*.

⁹⁴ Iskra–Janošić 1993, 198; Jeremić 2000, 143–144.

⁹⁵ Gluščević 1989, 73–74.

⁹⁶ Tentea, Ratiu 2014, 218.

⁹⁷ Jeremić 2000, 143–144.

⁹⁸ Tentea, Ratiu 2014, 218.

⁹⁹ As evidenced by two kilns discovered in Viminacium (Kiln 6 from the Craftsmen Centre and the kiln from the site of Više Grobalja) (Јордовић 1994, 97–98; Јовић et al. 2021, 133–141). Cf. Romeuf, Dumontet 1973; Peacock 1982, 69; Cuomo di Caprio 1972, 435.

¹⁰⁰ No tools that could have been used in any phase of the production process were ever identified, although some of the agricultural tools might have been used (cf. Ilić, Jovičić 2021)

¹⁰¹ For the presence of *Legio VII Claudia* in Viminacium cf. Benea 1983, 33, 42–75; Mirković 1986, 35–43.

organisation and specialisation. Their area, c. 1,280 m² and 800 m², places them in the category of larger workshops (>300–400 m²).¹⁰³ Their layout exhibits a high degree of rationality, as both the clay pit and the drying hall served multiple functions and were positioned in a way that best facilitated the production process and the organisation of labour. Unfortunately, the available data for Units 3 and 5 is not sufficient to provide any insight into its organisation of production. The same is true for production on the site of Provalije, although the sheer number, complexity and size of the discovered kilns indicate that it was a major production area with several workshops and large and organised production.

The kilns were commonly organised into batteries, each comprising two to three kilns around a common work platform, used during the firing of the kilns and for the storage of fuel. This practice was common and was used to ensure the easier and faster operation of the structures.¹⁰⁴ The pinnacle of this principle was the fusing of kilns into a single structure, a so-called “brick-plant”, which is noted in Unit 2. Such structures are characteristic of a highly organised and continuous production. The only exception to the above-mentioned practice is Unit 3 with Kiln No. 5, which appears to be a stand-alone. The explanation for this may lie in the size of the kiln, or the proximity to the other production units.

Military brickyards primarily operated simple kilns of the type II/b, but also the only two kilns of the complex type II/d. Compared to the other kilns from Viminacium, they fall into the category of larger kilns. This is in concordance with the general assumption that the kilns of higher capacity and greater complexity would be associated with better organised and larger workshops. Various techniques were employed in the construction of the kilns and, as already stated, not a single one was identical to another. This implies that their construction depended primarily on the experience and the skill of the builder.

The kilns were primarily used to produce CBM, but the finds of pottery and terracotta from the kilns of Unit 2 suggest that they may occasionally have been used to produce other ceramic material, most likely to supplement the burning stock of CBM. Additionally, some circular kilns discovered in the area of Units 2, 3 and Provalije – TEKO A may have been concurrent with the quadrangular kilns. Altogether, this suggests that the *Legio VII Claudia* produced various ceramic products¹⁰⁵ (pottery, lamps, terracotta, etc.) and, although there is ample evidence that the military units were engaged in

the production of various ceramic items,¹⁰⁶ until more straightforward evidence comes to light, this must remain only a hypothesis.

Other production (Units 1 and 6)

The production of CBM in the sites of Pirivoj (Unit 1) and Livade kod Čuprije (Unit 6) is harder to analyse, due to the nature and extent of excavation work and the available data. The immediate surroundings of the kiln at Pirivoj have not been excavated, but there are indications that it was part of a battery. This, and the adjacency of a major road could imply that it was part of a large workshop. The kilns in Livade kod Čuprije were seemingly isolated and their relationship to the nearby objects is impossible to define. As no products could be linked to the output of either workshop, it is impossible to determine the owners of the kilns, what they were producing, or their designated market. The proximity of both sites to the other military installations prompted the authors¹⁰⁷ to suggest that the kilns were part of the military production, but their position, differences in kiln size and the lack of stamped CBM make this less likely. They may have been privately owned, even if private CBM production was poorly documented in Viminacium.¹⁰⁸ If this was the case, they were most likely an estate production model¹⁰⁹ or, less likely, a peripatetic production model (i.e., mobile brickworks)¹¹⁰. Both models imply that the products were made for a predetermined purpose, to meet the demands of a single estate or object, or to supply construction works located in its vicinity. In both models, the requirement for tools and produc-

¹⁰² The cooperation between these two legions is well attested on the territory of Viminacium (Vasić 1905, 108), unequivocally in the CBM industry by a find of a tegula with the stamp LEGIIIFETVII, discovered built into one of the aqueducts of the city (Mrđić 2007, 25).

¹⁰³ Hasaki 2006, 225.

¹⁰⁴ Cf. Sultov 1985, 40; Hasaki 2002, 271.

¹⁰⁵ Raičković, Redžić 2005, 87.

¹⁰⁶ This is best exemplified by rare finds of military stamped pottery and lamps discovered in Nijmegen (Willems 1989, 213), Vindonissa (Schaer 2005, 45), Vindobona (Chinelli et al. 2018), Brigetio, Cannstatt and Aquincum (Peacock 1982, 147, 161; Vámos 2012).

¹⁰⁷ Jovičić, Redžić 2012; Jovičić, Milovanović 2017, 32.

¹⁰⁸ Contrary to the claims of some authors (Mirković 1968: 141; Spasić-Đurić 2002: 144).

¹⁰⁹ Peacock 1982, 10, 129–135; McWhirr 1984, 47–48; Darvill, McWhirr 1984, 255–256.

¹¹⁰ McWhirr 1984, 44–47; Darvill, McWhirr 1984, 254–255.

tion objects was minimal, the clay would be excavated in the vicinity, and the production was seasonal and organised to meet current needs.

CONCLUSIONS

The study gives a general outline of the CBM production in Viminacium, based on the current state of research. Unfortunately, virtually all the finds presented in this study have come to light during the limited rescue excavations, which has, thus, limited our ability to reconstruct the workshops. The layout of the manufacturing sites and the analysis of the structures allowed some insight into the production process and discussion of its organisation. It is obvious that the military was the main producer of CBM in Viminacium. It operated two large-scale production areas with several workshops, which were characterised by highly organised production and high output. The manufacture was located on two additional sites, but the lack of adequate data makes any detailed analysis of its production difficult.

Our study shows that the CBM production in Viminacium was a major enterprise. Yet, it is nothing more than the latest step in a long research journey, as it exemplifies that many aspects require further investigation. It is our belief that the prerequisite for any future study should be a more thorough chronological analysis of the discovered sites and finds. This will provide a better understanding of the development of

CBM production in Viminacium. Additionally, an in-depth interdisciplinary study of both the structures and the products (CBM and other various ceramic finds) is needed. This will provide an insight into other economic aspects of production, especially defining the products of the individual workshops, their distribution, designated markets and usage, as well as those factors that influenced the whole production process. Luckily, as vast portions of the site remain unexplored, we are certain that future discoveries in conjunction with further study of previously discovered remains and finds will provide additional insight into the intricacies of the CBM industry of ancient Viminacium and, more importantly, its usage, as it truly was one of the key building materials of ancient Viminacium.

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ПРОИЗВОДЊА КЕРАМИЧКОГ ГРАЂЕВИНСКОГ МАТЕРИЈАЛА У АНТИЧКОМ ВИМИНАЦИЈУМУ

Кључне речи. – римска производња керамичких грађевинских материјала, Виминацијум, цигларске пећи, Пећине, Провалије, Ливаде над Ђупријом, Пиривој, Костолац

Технологија производње и употреба печене опеке представља иновацију коју на простор средњег Подунавља уводе Римљани. На археолошком налазишту Виминацијум интензивна производња и употреба овог материјала почиње од краја 1. века н. е. Упркос небројеним налазима опека и бројним производним објектима, овај аспект римске економије античког Виминацијума је слабо познат. Стога, овај рад представља анализу до сада откривених производних објеката са циљем да се сагледа процес и организација производње на Виминацијуму.

Приликом досадашњих истраживања античког Виминацијума откривено је преко 15 пећи и више објеката за прављење опека на 4 локације. Једна пећ је откривена на локацији Пиривој (радионица 1), међутим, њена околина није истражена, иако постоје индикације да је у питању већа радионица. Највећа концентрација производних објеката је идентификована на локацији Пећине, где су откривене 4 радионице. Највећа и најбоље истражена радионица је Занатски центар (радионица 2), са глиништем, бунаром, халом за сушење, три пећи за печење опека и више мањих пећи за печење другог керамичког материјала. Радионицу 3 чини једна велика пећ, сложеног типа са два ложишна канала, а радионицу 4 две пећи на ободу велике јаме – глиништа. Радионицу 5 чине једна пећ и глиниште. Према западу, две пећи су идентификоване на локацији Ливаде код Ђуприје (радионица 6), у непосредној близини античке виле. У близини ових пећи откривено је више структура за производњу керамичких материјала, међутим, услед ограничености доступних података њих није могуће са сигурношћу везати за пећи. Друга велика производна област откривена је на супротној обали реке Млаве, на локацији Провалије – ТЕКО А. На овој локацији откривено је више од пет правоугаоних пећи за опеке (радионице 6 и 7), међутим, доступни подаци не омогућавају изношење закључака о организацији ових радионица.

Откривени остаци указују да је на Виминацијуму глина ископавана у великим јамама-глиништима, лоцираним у непосредној близини радионица, какве су откривене у склопу радионица 2, 4 и 5, док је вода најчешће црпљена

бунарима (радионице 2 и 6?). Порекло песка, као и гориво коришћено за паљење пећи није могуће утврдити. Глинена смеша је обрађивана у јамама, чији је број несразмерно мали, али постоје индикације да је овај процес могао бити вршен и у деловима великих јама-глиништа. Трагови даље обраде су ретки и само се један објекат може везати за овај део производног процеса – хала за сушење опека у склопу радионице 2 (Занатски центар). Из овог разлога претпоставка је да су опеке махом прављене и сушене на отвореном. За печење опека су најчешће коришћене пећи правоугаоног облика са једним ложишним каналом (тип II/b према Cuomo di Caprio 1978/1979), а ређе и веће пећи комплекснијег типа са два ложишна канала (тип II/d). У склопу поменутих радионица нису откривени остаци објеката за смештај људства и складиштење алатки и сировина.

Покретни налази указују да је производња на локацији Пећине и Провалије – Теко А била под управом VII Клаудијеве легије, а истражени објекти сведоче да је производња високо организована и великог обима. Одликују је веће пећи једноставног облика и једине две пећи сложенијег облика и знатно већег капацитета. С друге стране, доступни подаци нису довољни како би се дефинисао карактер радионица на локацијама Пиривој и Ливаде код Ђуприје. Како ни у једном од ова два случаја нису откривени покретни налази, није могуће утврдити власнике ових радионица.

Досадашња истраживања су показала да је опекарска индустрија у Виминацијуму била развијена и великог обима. На основу доступних података, јасно је да је војска била главни произвођач керамичких грађевинских материјала, међутим, ово не искључује могућност развијене приватне производње, каква је можда откривена на локацијама Пиривој и Ливаде код Ђуприје. Нажалост, сви наведени налази откривени су приликом заштитних археолошких истраживања, што у знатној мери ограничава могућности истраживања. Нова открића и будуће студије, како самих радионица и објеката производње, тако и производа ових радионица, значајно ће допринети разумевању опекарске индустрије, а тиме и живота и развоја античког Виминацијума.