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VAULTING TUBE PRODUCTION IN *DACIA MEDITERRANEA*: A CASE STUDY FROM THE *STRYMON* VALLEY IN ITS REGIONAL CONTEXT

IN MEMORY OF MY FATHER

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Abstract: In 2017 a new Late Roman settlement was discovered on the road bed of the Struma Highway, near the modern day village of Moshtanets, Blagoevgrad district. The archaeological site was located on a slope and adjacent river terrace, close to the right bank of the Struma River (ancient *Strymon*). During the excavations, a ceramic kiln and a deposit of ceramic tubes were discovered in its southern sector.
This contribution is aimed at presenting both the kiln and the finds, identified as terracotta vaulting tubes (*tubi fittili*). The latter are described and analysed in the context of similar artefacts from the northern half of the Balkans, and especially from within the Late Roman province of *Dacia Mediterranea*. In conclusion, some observations are made concerning the purpose and possible recipients of these locally made products.
Keywords: *Moshtanets, vaulting tubes, local production, Late Roman period, Dacia Mediterranea.*

In 2017 a new Late Roman settlement was discovered on the road bed of Struma Highway, near the modern day village of Moshtanets, Blagoevgrad district. The archaeological site was located on a slope and adjacent river terrace, close to the right bank of the Struma River (ancient *Strymon*)[1] (Fig. 1.1[2]).

During the excavations, a ceramic kiln and a deposit of ceramic tubes were discovered in the southern sector of the site[3]. This contribution is aimed at presenting both the kiln and the finds. Furthermore, its goal is to explore the possibilities for local production of these tubes, and, through finding similarities with identified parallels from other sites, determine their precise function and possible designation.

I. THE ARCHAEOLOGICAL SITE

The rescue excavations in 2017 revealed a previously unstudied Roman and Late Roman settlement with adjacent necropolis. Several buildings were

[1] GROZDANOVA/HRISTOVA/FILIPOVA 2018, 377.
[2] The border line between the provinces of *Dacia Ripensis* and *Moesia Secunda* in the presented map is traced along the Osam River, and not along the Vit River (as in the cited sources), according to the research of S. Torbatov, who recently presented credible evidence for the former (see TORBATOV 2016, 238-240).
[3] GROZDANOVA/HRISTOVA/FILIPOVA 2018, 378-380.

Fig. 1. Map with find-spots of vaulting tubes and vaulting pots in *Dacia Mediterranea* and the neighbouring provinces from the 3rd – 4th c. AD /with provincial and diocese borders of the 4th c. AD and abbreviated provincial names: Mc – *Macedonia*; Dd – *Dardania*; MP – *Moesia Prima/Superior*; DR – *Dacia Ripensis*; DM – *Dacia Mediterranea*; MS – *Moesia Secunda/Inferior*; Sc – *Scythia*; Hm – *Haemimontus*; Thr – *Thracia*; Eu – *Europa*; Rh – *Rhodope* (provincial borders after DINTCHEV 2006, 99, Fig. 1; BĂJENARU 2010, 231, Pl. 1, with additions and corrections by A. Harizanov).

unearthed within the southern part of the archaeological site (Sector 1), with several more found in its central zone (Sector II). The latter have been separated from the nearby necropolis (Sector III) by a stone wall, supposedly erected for the purpose (Fig. 2). The buildings and facilities from Sector I were dated between the 3rd and the third quarter of the 4th c. AD, the ones from Sector II – to the 4th c. – first half of the 5th c. AD. *Terminus post quem* for the use of the necropolis is a coin of Nerva found in one of the graves, while its terminal date has been set close to the mid- 4th c. AD[4].

During the Roman period this section of the Struma valley was part of the city territory of *Pautalia*, within the province of Thrace[5]. The border between the latter and *Macedonia* was probably located no less than 15-20 km to the South of Moshtanets, near the Kresna Gorge[6] – an 18 km long steep valley, formed by the Struma River, which served as a natural border between the two provinces.

One of the last epigraphic documents, proving the affiliation of this region to the territory of *Pautalia*, was the famous letter of the inhabitants of the village of *Scaptopara* to emperor Gordian III and his response, composed in the AD 238[7]. Whether the modern Blagoevgrad district was still part of the territory of the Roman city after the establishment of the new province of *Dacia*, later *Dacia Mediterranea*[8], it is

[4] GROZDANOVA/HRISTOVA/FILIPOVA 2018, 379-380.
[5] See GEROV 1988, 139-140; TATSCHEVA 2004, 87-88.
[6] GEROV 1988, 140. According to M. Tatscheva the border line passed to the South of the gorge (TATSCHEVA 2004, 88).
[7] GEROV 1988, 169-170.
[8] *Dacia* (*Dacia Aureliana*) was founded by Aurelian in AD 271-272, after

Fig. 2. General plan of the Moshtanets archaeological site with find-spots of the ceramic kiln and the tube deposit (after GROZDANOVA/HRISTOVA/FILIPOVA 2018, 378, Fig. 1, with additions by A. Harizanov).

unclear[9]. However, there is also no evidence for its inclusion in the neighbouring province of *Macedonia* (later split into *Macedonia Prima* and *Macedonia Salutaris* (afterwards *Secunda*))[10]. So, for the time being, it seems more plausible that during the late 3rd and the first half of the 4th century the region remained under the administration of *Pautalia*, or at least within the limits of *Dacia Mediterranea* (Fig. 1)[11].

II. THE CERAMIC KILN

The kiln was found in Sector I (square E5), situated in a relatively flat terrain near a rising slope to the West, where a cluster of buildings has been excavated (Fig. 2)[12]. It was dug partly into a layer of brownish soil, with low concentration of ceramic material, and partially into a yellowish sterile stratum (Fig. 3).

The installation belongs to the two-chambered kilns with vertical draught. The combustion chamber was sunken, with close to circular floor plan (Fig. 4; Table 1). It has been shaped into the ground and lined with clay plaster. The bottom of the chamber followed the natural slope of the terrain. A central pillar of rectangular plan was found inside the chamber. It was erected of five horizontal layers of fragmented bricks and an upper layer of stones, all bonded and plastered with clay. The perforated floor was made of stones, fragmented bricks and tiles, among which two concentric circles of ventilation openings were shaped. The upper layer of the oven floor was made of several centimetres thick plaster of clay. Only part of the western side of the wall of the firing chamber, which was originally situated below ground, was found *in situ*. The stoking channel and the stoke pit were found to the East of the combustion chamber, dug into the sloping terrain. The stoking channel has been tunnelled between the chamber and the stoke pit. Its walls were shaped into the soil and plastered with clay. The bottom of the channel was found covered with a thin layer of ash, left from the last firings of the installation. The stoke pit had an oval floor plan and sloping walls. It was found filled with brown to dark brown soil and a small number of pottery and tile sherds. The bottom of the pit near the channel was slightly fired. The upper part of the pit, on the opposite side, was partially overlaid by a concentration of stones and tile fragments, probably left from a construction, postdating the use of the kiln (Figs. 3-9).

In concordance with the floor plan of the combustion chamber and that of the support for the perforated floor, the kiln could be associated with the installations of type I/a from the typology of the antique ceramic kilns from the territory of modern Bulgaria, which were the most common structures in the region during the pre-Roman, Roman and Late Roman periods[13]. As customary in the time after the Roman conquest of Thrace, the installation was built partially of reused ceramic building material[14], which is also an indication for the presence of earlier constructions in the nearby area.

An archaeomagnetic study on samples from the kiln provided a date for the last firing of the installation between AD 286 and AD 334[15], which corresponds with the archaeological dating of the finds from the surrounding area[16].

the abandonment of the Dacias to the North of the Danube (WATSON 2003, 134). However it is still unclear whether it was originally formed as one or two provinces. The first mention of two Dacias (i.e. two provinces) comes from an inscription dated to AD 283, during the joint rule of Carus and Carinus (see FILOW 1912, 234-239; VELKOV 1977, 62, note 175). However, there is also an opinion that very soon after their establishment Diocletian might have united the two Dacias (*Mediterranea* and *Ripensis*) into one province and that their final division happened in the course of the 4th century, but before AD 386 (see BĂJENARU 2010, 13, note 5, and the cited literature).

[9] VELKOV 1977, 93.

[10] For the history and territory of the Late Antique province of *Macedonia*, later split into *Macedonia Prima* and *Salutaris* (later *Secunda*), see SNIVELY 2010, 545-571; VESEVSKA 2019, 145-154.

[11] For instance, the city of *Bargala*, which was part of *Dacia Mediterranea* at least until AD 371, has been transferred during the 5th or the early 6th century to the province of *Macedonia* (*Macedonia Secunda*) – see VELKOV 1977, 98; SNIVELY 2010, 549-550. So it is possible that similar changes occurred in this later period elsewhere, but for now no such information exists.

[12] The description of the kiln is based on my personal observations, made during the excavation of the facility in August 2017.

[13] See HARIZANOV 2019a, 86-89; HARIZANOV 2019b, 27.

[14] HARIZANOV 2019b, 28.

[15] The analysis was made by the team of Prof. Dr. M. Kovacheva and Assoc. prof. Dr. M. Kostadinova-Avramova from the National Institute in Geophysics, Geodesy and Geography – BAS.

[16] Additional information, provided by the Dig Director of the site, Dr. Galina Grozdanova (assistant professor, NAIM-BAS).

Table 1. Dimensions of the preserved components of the Moshtanets kiln.

Internal dimensions (in cm)	Combustion chamber	Support	Perforated floor	Firing chamber	Stoking channel	Stoke pit
Diameter	72	-	70-72	70-72	-	-
Width	-	20-22	-	-	43	80
Length	-	32	-	-	60	1.10
Height / depth	28-45	30-35	-	?	35-45	28
Wall / oven floor thickness	10-12	-	12-14	10	8-12	-

III. THE CERAMIC TUBES

More than 30 ceramic tubes were found deposited into a pit, located inside one of the premises of building no. 1. The assemblage consisted of almost entirely preserved examples as well as fragmented pieces. Some of the finds had traces of mortar, most often on their outer surface (Fig. 10)[17].

Two major types of tube shapes were recognised, both wheel-made and hollow. At least some of the finds could have had separately made bodies and nozzles, which were attached to one another while still not thoroughly dry.

The first type of tubes (type I) comprised examples with thick, cylindrical bodies, broad, square shoulders (some with a shallow groove on the upper side) and conical nozzles (Fig. 11; Table 2). Some of them had slightly curved or inclined bodies and/or asymmetrical shoulders. The fabric was overall fine, with sand, mica and smaller quantities of gravel being used as tempers (Fig. 12). The tubes were evenly fired, with orange-beige to orange-red colour of both sides and the cross-section. Their outer surfaces were mostly smoothed, while some of the bodies and/or the nozzles had production marks or (more likely) purposely left diagonal and horizontal wheel-made grooves. The internal surfaces were smoothed, most often only in the lower part of the bodies and upper part of the nozzles (near the two opposite openings), and also at the junction points between the two parts (body and nozzle).

The second type of tubes was of similar fabric and colour to the first one. The major divergence between this and the previous group is in the overall shape and thickness (Figs. 13-14; Table 2). The tubes of type II had thinner and smaller in diameter bodies, again with close to cylindrical shape, but in some cases with visible narrowing in the central part (Fig. 15). In one case, the entire body had slightly conical shape. The shoulders of these tubes were narrower than those of the first one, only occasionally with a shallow groove on top, while others were directly protruding to the nozzles. The latter had conical lower and cylindrical upper parts. Some of the tubes had smoothed external sides, while others had visible wheel-made horizontal or slightly diagonal grooves.

The erection of building no. 1, where the tubes were found, is dated to the last quarter of the 3rd c. AD, while its final period of use is dated to the 360s. In concordance with this dating, the tubes were most likely deposited into the pit at some point between the late 3rd and the first half of the 4th c. AD[18].

Apart from the deposit, several stray finds of almost entirely preserved and fragmented tubes, discovered in the same sector as the kiln and the assemblage, proved important for the present study. One of these finds was an overfired example (Fig. 16), while another was a fragment of production waste (Fig. 17), both with the characteristics of the tubes of type I. In addition, some of the tubes of both types, found within the deposit, had minor traces of over-firing.

IV. DISCUSSION

1. The tubes – local production or imports

The discovery of both firing installation and production waste of similar dating with the deposit is a strong indication for the local production of most of the tubes. Furthermore, the relatively small size of the kiln could serve as an indication for its purpose – firing of small to medium sized clay-formed objects[19]. Of course, it cannot be excluded that some of the tube finds could have been imported and used as models for the locally made items[20]. Also worth noting is the possibility of simultaneous (or interchanging) firing of the tubes with other ceramic articles, needed in the everyday life of the villagers[21].

Having in mind the internal diameter of the kiln's firing chamber and two reliable possibilities for the reconstruction of its superstructure[22], it could be estimated that between 90 and 120 tubes could have been fired there at once. The tubes were most likely positioned standing on their lower sides and placed inside one another, on several tiers (Fig. 18). Such an arrangement could have enabled the good circulation of the hot air coming from the combustion chamber and the thorough firing of the manufactured artefacts. Similar

[17] The description of the tubes is based on my personal observations, when studying the finds. Most of drawings were made by Kristina Koseva (PhD Candidate, NAIM-BAS).

[18] Additional information by Dr. Galina Grozdanova.

[19] For examples of kilns of similar size and supposed function, see HARIZANOV 2019a, 387; 471-472; 491-492; 525-526; 541; 567-569, etc. A very simple explanation for the preference of small vs. bigger kilns is the need of much smaller amounts of fuel for the firing of the limited number of artefacts usually produced by such workshops.

[20] Vaulting tubes, for example produced in North Africa, were subjected to export as proved by the finding of such items among the cargos of sunken ships – see discussion and cited literature below.

[21] The lack of specialisation and the local production of most of the needed ceramic items were common for certain stages of the Late Antique period in the Balkans (see HARIZANOV 2019a, 121; 192-199).

[22] For the superstructure of the Roman and Late Antique kilns in the territory of modern Bulgaria, see HARIZANOV 2019a, 60-65; HARIZANOV 2019b, 16; 24.

Table 2. Dimensions of the Moshtanets tubes (based on examples with entirely preserved body parts).

Dimensions → (min. – max., in cm) Tube type ↓	Overall height	Body height	Nozzle height	Body thickness	Nozzle thickness	Shoulders diameter	Body inner diameter (bottom)	Nozzle upper (outer) diameter	Nozzle lower (outer) diameter
Type I	20.8-23	11.8-16.2	6.6-7.6	1.6-2.2	1.1-1.7	11.9-14.2	8.1-10.6	5.1-5.6	7.8-9.2
Type II	21.8-22.5	13.5-16.3	6.8-7.8	0.8-1.6	0.6-1.3	9.6-11.1	7.8-9.6	5.2-5.7	7.2-8.1

internal organisation (but of kiln furniture and not fired products) had the Roman sigillata kilns of Western Europe, where specially designed tube constructions were used as chimneys (having them placed atop the ventilation openings of the perforated floor) thus separating the fine wares from the ash and smoke from the fire and at the same time allowing good air circulation and even distribution of the heat inside the entire upper chamber[23].

2. The tubes – design, function and origin

The tubes from the assemblage have relatively short hollow bodies (in relation to their internal diameter), almost square or narrow shoulders and open conical nozzles. In addition, their sometimes asymmetrical shoulders and inclined bodies (most often observed on tubes of type I), and especially the smaller external diameter of the nozzles in relation to the internal diameter of the tubes' bases, could have all been purposely made. This design is typical for the so-called terracotta vaulting tubes (Fig. 19), which were used for the erection of internal domes, vaults and similar architectural constructions across the Empire.

Vaulting tubes (Latin *tubi fittili*) first appeared during the 3rd – 2nd centuries BC. The examples known to date, come from the sites of Morgantina in Sicily and Cabrera de Mar near Barcelona in Spain[24]. These first tubes were different to the shapes described here – much longer and without nozzles (so-called "bullet shape"), and were designed so that each tube could fit into the adjacent one and afterwards be filled, bonded and covered in mortar. They were found in bath buildings, erected before the implementation of Roman concrete, and their presence was most likely owed to the need for safer and longer lasting constructions[25].

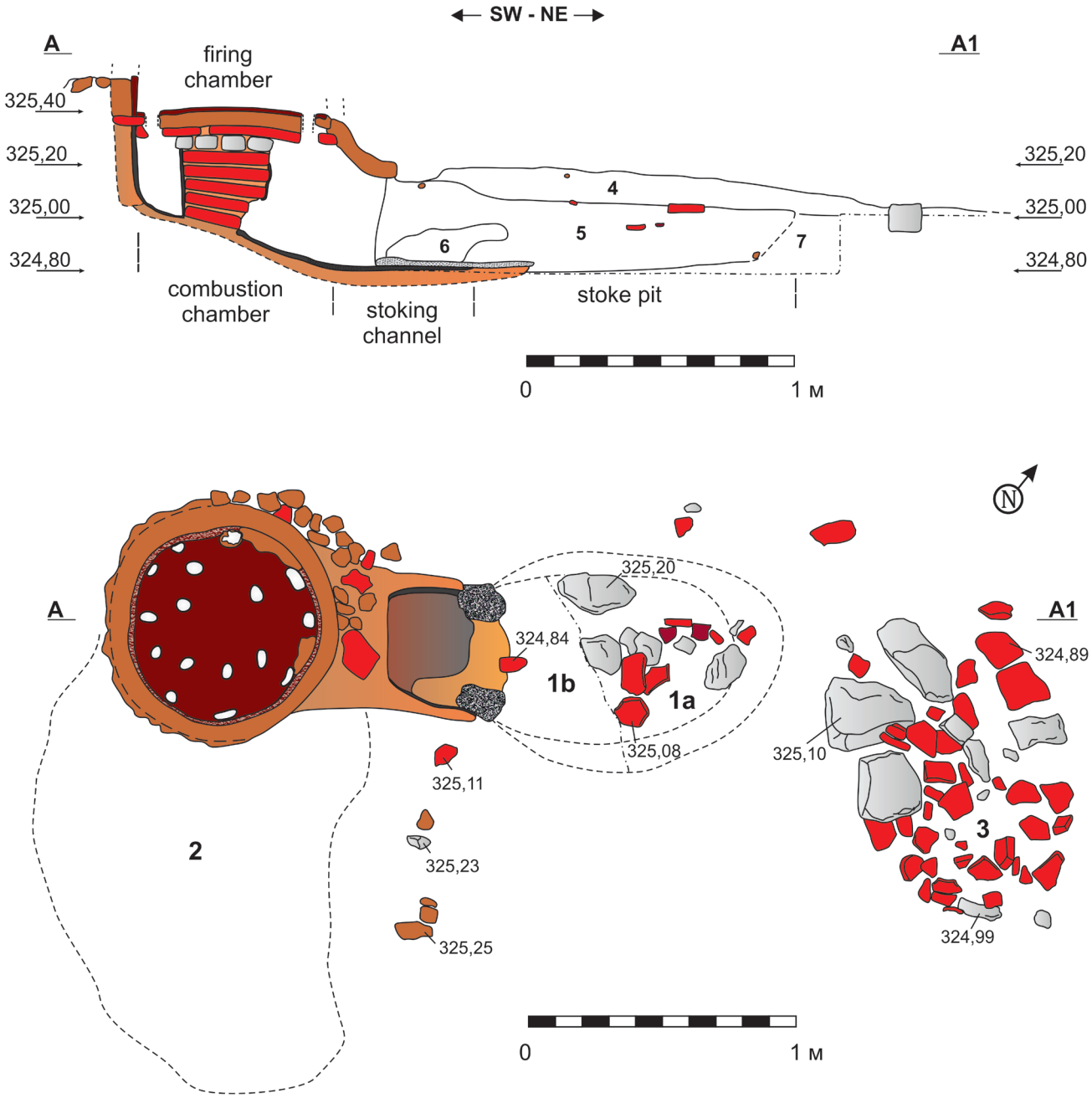
After this initial period of experimentation, during the centuries before and after Christ when bullet-shaped tubes were used in baths, vaulting pots (also termed as kiln pots; some close in shape to conventional cooking pots) were often employed in the erection of kilns' firing chambers. The first known examples from Italy date to the 2nd – 1st c. BC, while the ones from *Pompeii* in particular have a *terminus ante quem* in AD 79. During the Augustan period the technique had already spread to the territory of France, while in the 2nd and 3rd c. AD it is attested along the Rhine limes and also in the East (*Pompeiopolis*). According to L. Lancaster, the use of vaulting pots for the erection of kiln superstructures was common up to the 3rd c. AD[26]. However, vaulting tubes seem to have been used for the same purpose even later, for example in the region of ancient *Sinope* where a number of kiln domes were built in this way between the 4th c. and the 6th or even the 7th c. AD[27].

The continuation of the technique, precisely for the use of vaulting tubes in buildings (apart from single examples), has been traced to North Africa, where it first appeared during the 2nd c. AD and became widespread around the end of this, and throughout the next, century. It was in the aforementioned region that the tubes with nozzles seem to have been developed (first in tomb architecture), which according to L. Lancaster allowed for their easier use (the better and more sturdy fit excluded the need for wooden frames) along with a greater diversity of vaulting shapes being made possible. They were found in the context of both public and private buildings, but their application is best attested in bath complexes[28]. During the Early Byzantine period vaulting tubes were also used in the construction of religious buildings, such as the San Vitale church at Ravenna[29].

The initial spread of nozzle tubes during the Severan period is ascribed mainly to the army, with cited examples from military sites in both North Africa (*Lambaesis*, Bu Ngem, *Aquae Flavianae*) and the rest of the Empire (Caerleon, Chester, York, Dura-Europus)[30]. Another key factor in the exportation of the technique is believed to be the increase in production and distribution of African goods, such as grain, wine, olive oil, fish products and also ceramic fine wares and oil lamps, starting from the 2nd c. AD onwards[31].

Vaulting tubes have been occasionally discovered in shipwrecks (usually along with amphora-borne commodities and sometimes fine wares)[32] near the coasts of Italy (including Sicily and Sardinia), Spain, France and the Adriatic, and in one case – in debris from a harbour deposit[33]. While at least some of the wreck finds could have been a minor side export product (to be used as a model for local producers?) or parts of ship-bound construction[34], others, for example the Levanzo I deposit with its more than 150 preserved tubes (out of maybe 400-500), were almost certainly a share of a trade cargo[35].

[23] See for instance DESBAT 1993, 361-370; REUTTI/SCHULZ 2010, 567-587, and the cited there references.
[24] WILSON 1992, 105-107; MORENO ALCAIDE/ROMÁN PUNZÓN/RUIZ MONTES 2019, 134-135.
[25] WILSON 1992, 108; LANCASTER 2015, 100-105.
[26] LANCASTER 2015, 105.
[27] KASSAB TEZGÖR/ÖZSALAR 2010, 199-216.
[28] WILSON 1992, 102-105; LANCASTER 2015, 106-108.
[29] WILSON 1992, 117-118; LANCASTER 2015, 114; 126.
[30] LANCASTER 2015, 108-112.
[31] LANCASTER 2015, 112-114.
[32] WILSON 1992, 119; LANCASTER 2015, 115; ROYAL 2015, 135-138.
[33] See VANN 1993, 29-34, for the discovery of two nozzle tubes of uncertain context and date within debris from the harbour of *Caesarea Maritima*.
[34] WILSON 1992, 120; LANCASTER 2015, 115.
[35] See ROYAL 2015, 127-144, for the description of the deposit, the



stones
brick and tile fragments
pottery sherds
fired soil (below the bottom of the stoking channel)
fired soil (walls of the stoking channel)
fired clay
layer of ash and charcoal
blackened clay plaster (lining of the stoking channel)
fired clay lining covered in ash (bottom of the stoking channel)
fired clay lining (upper side of the perforated floor)
fired clay lining (inner face of the walls of the firing chamber)

1a - stoke pit, upper level
1b - stoke pit, lower level
2 - cluster of pieces of fired clay
3 - cluster of stones and fragments of ceramic building material (remains of another construction)
.....
4 - brownish stratigraphic layer, related to the period post-dating the use of the kiln
5 - a layer of brown to dark brown soil mixed with debris, accumulated after the abandonment of the kiln
6 - destructions (fired clay and dirt) from the walls of the stoking channel
7 - a layer of yellowish sterile soil

Fig. 3. The ceramic kiln – plan and cross-section (author A. Harizanov).

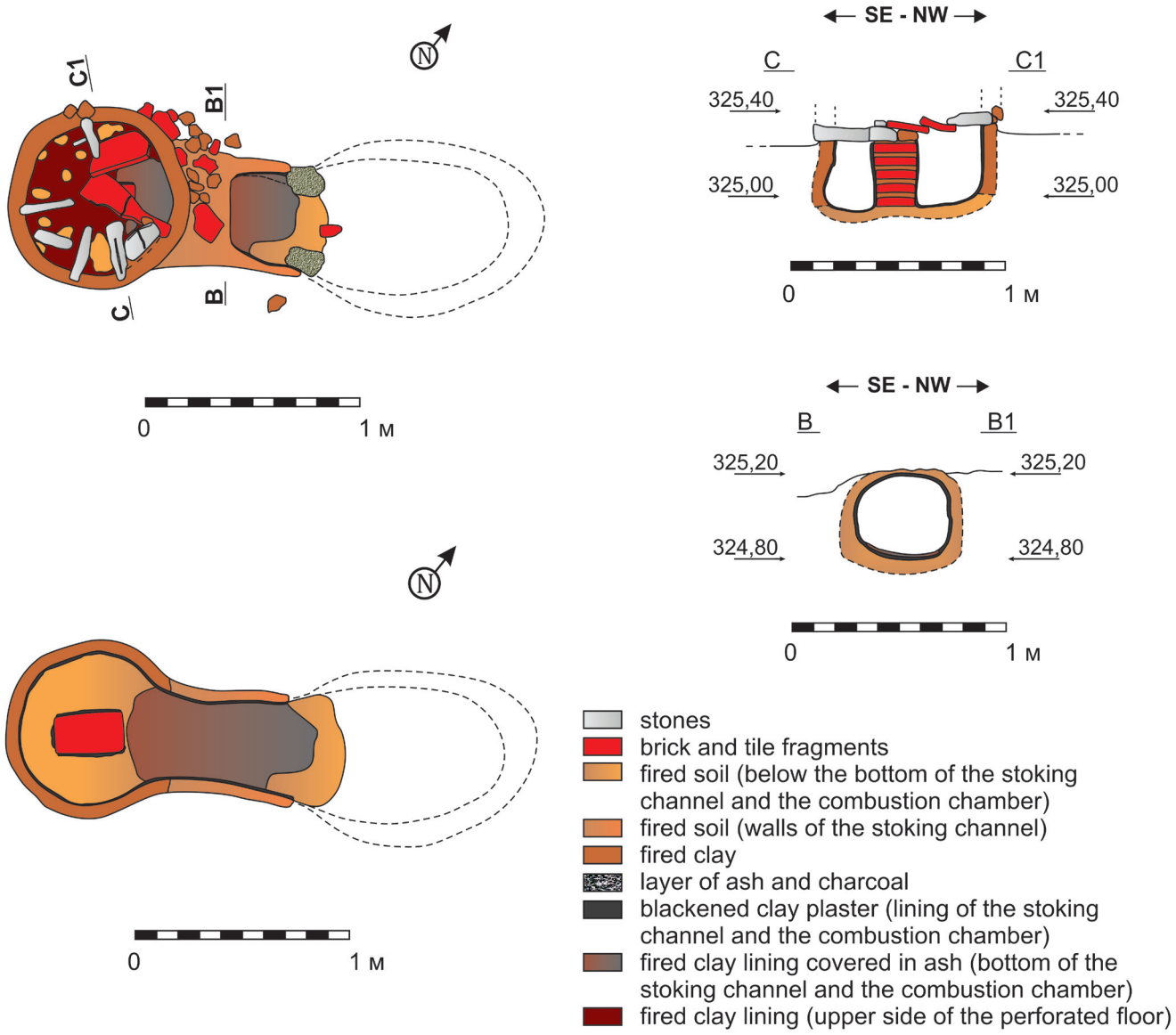


Fig. 4. The ceramic kiln – plans with the lower part of the perforated floor and the combustion chamber, and cross-sections of the perforated floor and the stoking channel (author A. Harizanov).

3. VAULTING TUBES AND VAULTING POTS IN THE BALKAN PROVINCES OF THE EMPIRE

Initially thought to have been distributed mainly in North Africa and the western part of the Empire[36], the use of vaulting tubes appear to have been also common for the Roman and Late Roman Balkan provinces. A case study for the site of *Timacum Minus* (located within the Roman *Moesia Superior* and the Late Roman province of *Dacia Ripensis*) have provided data for the discovery of such items also in *Lychnidus* (*Epirus Nova*), *Sirmium* (*Pannonia Inferior, later Pannonia Secunda*), *Viminacium* (*Moesia Superior*, later *Moesia Prima*), *Drobeta* (*Moesia Superior/Dacia*, later *Dacia Ripensis*), *Novae (Moesia Inferior,* later *Moesia Secunda)*, *Sarmizegetuza*, *Apulum*, *Potaissa, Jidova* (all four located within the Dacias beyond the Danube that existed until the reign of Aurelian) etc., with most of the cited examples coming from contexts of the 3rd and the 4th c. AD[37]. Nozzle tubes of similar design were also discovered in the Roman fort at Gherla, again in *Dacia* (*Dacia Porolissensis*), where the finds were conversely described as water pipes[38]. Yet, the most interesting case from *Dacia* is to be found near the Roman fort at Brâncovenești, where a deposit of 107 nozzle tubes was discovered inside an extramural ceramic workshop. One of the tubes bore an imprint of a replica of a denarius of Marcus Aurelius (issued in AD 144), while the workshop probably functioned during the second half of the 2nd and the beginning of the 3rd c. AD[39].

The close relationship between the initial spread of this technology with the military proposed for the Severan period, seems to fit quite well with the evidence from the region in question. Such was most likely the case for of the finds from *Potaissa,* Jidova, Brâncovenești and Gherla (?), while those from *Sirmium*, *Viminacium*, *Drobeta* and *Apulum*

shipwrecks known to date and the possibilities for trading vaulting tubes as one of the supplementary products of *annona* shipments.

[36] WILSON 1992, 113-121.

[37] BJELIĆ/NIKOLIĆ 2020, 173-199.

[38] See PROTASE/GUDEA/ARDEVAN 2008, 470, Pl. LXI/6; 478, Pl. LXXI.

[39] SIDÓ 2018, 55-68.

were discovered in civic public buildings, but in both cases (military and civic) mainly identified as baths[40].

The artefacts from the territory of modern Bulgaria also come from both military and civic contexts. The examples from *Novae* (Fig. 20) were found within the large legionary baths, and were most likely used in a reconstruction of the complex, which occurred in the Severan period or between the reigns of Gordian III and Constantine the Great[41].

Vaulting tubes with conical nozzles were found again in a bath complex (the south-eastern baths) at *Oescus* (a legionary camp, later Roman *colonia* and finally a Late Roman town with military garrison, firstly within the province of *Moesia Inferior*, later incorporated in *Dacia Ripensis*)[42]. However, the use of the building, placed roughly in the 3rd – first half of the 4th c. AD[43], does not provide enough evidence for the precise dating of the tubes' appearance in the town's architecture.

Vaulting tubes or pots (described as conical, without nozzles and with one end closed)[44] were used in a bath building from the supposed Roman villa and centre of an imperial domain at the modern village of Madara, near Shoumen (*Thracia/Moesia Inferior*, later within the province of *Moesia Secunda*) (Fig. 1.5)[45].

Open cylindrical-conical vaulting pots were found on the site of a possible Roman sanctuary and later Early Byzantine port town on St. Atanas cape near modern day Byala, Varna region (within the Roman province of *Moesia Inferior*, later part of *Moesia Secunda*) (Figs. 1.6 & 21). The finds were discovered within the remains of a mid-3rd c. AD kiln and were most likely used for the erection of its superstructure[46], although other possibilities have also been noted[47].

For now, the use of nozzle tubes in the territory of modern Bulgaria is best attested precisely within the limits of the Late Roman province of *Dacia Mediterranea,* where such items are found in the towns of *Serdica*, *Germania*, at the Late Roman residential complex *Scretisca* near *Serdica*. Lastly, the place of discovery, which is closest geographically to the site at Moshtanets, is located in the vicinities of the modern village of Poleto, near Simitli, on the left bank of the Struma River, very close to the northern side of the Kresna gorge.

In the town of *Serdica* (a military establishment, later a Roman and finally a Late Antique town, first incorporated into the province of *Thracia*, afterwards capital of *Dacia Mediterranea*)[48] two nozzle tubes filled with mortar were found in a long vaulted room (Fig. 22A), part of a supposed *mithraeum* from the late 3rd – early 4th c. AD[49]. The finds had cylindrical bodies and conical nozzles, with the overall shape being closer to type II of the Moshtanets assemblage[50].

Vaulting tubes filled with mortar were also discovered during the excavations of the Late Roman residential complex *Scretisca* and the Early Byzantine fortress *Кратиσкара* near nowadays Kostinbrod (Fig. 1.4). Unfortunately, the finds have been reused as building material outside their original context so their precise location within the residential complex is unknown[51].

Nozzle tubes, again filled with mortar, were found during the 1950s excavations in the Roman auxiliary fort and Late Roman town of *Germania* (nowadays Sapareva Banya) (Figs. 1 & 22B). These finds had shorter cylindrical bodies and almost cylindrical nozzles (with both tube parts having slightly smaller diameters in their middle areas). The discovery of the tubes in a disturbed context does not allow their attribution to any specific type of building or precise dating (the rest of the materials and the excavated buildings were dated to the 3rd – 6th c. AD)[52]. In the same article, unpublished examples of vaulting tubes, found in the Early Byzantine fortress at Hisarlaka next to *Pautalia* (modern Kyustendil) and a site near the village of Kadin most (modern Nevestino – Fig. 1.3), are mentioned[53].

Of interest to the present study are also the tubes discovered during the excavations of a production site situated next to a presumed (but not investigated) Roman *vicus* in the vicinities of the modern village of Poleto, Simitli district (Fig. 1.2). The archaeological site was unearthed in the course of construction work near the Struma River in the 1980s. One lime kiln, a water fountain and a ceramic kiln were excavated. Among the large amount of ceramic material (building ceramics, coarse and fine wares, oil lamps) were several tubes[54]. While some could have been used as water pipes, the rest of the illustrated finds have characteristics similar to those of *tubi fittili* (Fig. 23). The tubes in question have cylindrical bodies and cylindrical or slightly conical

[40] BJELIĆ/NIKOLIĆ 2020, 175-176.

[41] See BIERNACKI 2016a, 11-66; JASIEWICZ 2016, 87-118, for detailed description and chronology of the baths, BIERNACKI 2016b, 67-86 – for the used ceramic building material and the vaulting tubes in particular. See dimensions (taken by the available drawings from the original publication) in Table 3.

[42] For the history of the military camp of *Legio V Macedonica*, the Roman *colonia* founded by Emperor Trajan and the Late Roman town with a military garrison, see for instance IVANOV/KOVACHEVA 2002, 31-58.

[43] See IVANOV 2006, 154-155.

[44] See dimensions (taken by the available drawing from the original publication) in Table 3.

[45] See ANTONOVA 1960, 34-37, for the discovered tubes; see DREMSIZOVA-NELCHINOVA 1984, 74-124; DINCHEV 1997, 74-79, for overall description of the archaeological site, its chronology and function. For the territorial affiliation of the presumed domain in the Roman period, see lastly HARIZANOV 2020, 104-105, and the cited literature. For the Late Antique period, see VELKOV 1977, 106.

[46] See HARIZANOV 2019a, 379-380. Both the place of discovery of the pots (inside the combustion chamber and the stoke pit) and the traces of over-firing (or multiple firings?) on some of their surfaces are indications for such use.

[47] See YOTOV 2019, 55-63.

[48] For the earliest development of *Serdica*, see lastly IVANOV 2020; for the post-Trajanic period of the town and its territory, see GEROV 1988, 164-168; VELKOV 1977, 93-95; BOYADJIEV 2002, 125-180.

[49] See BOBCHEV 1955, 207-217.

[50] See dimensions (taken by the available drawing from the original publication) in Table 3.

[51] See DINTCHEV 2003 for the excavations of the Late Roman residence and the fortress built on top of it during the Early Byzantine period. For the tubes in particular, see DINTCHEV 2003, 84, note 280.

[52] See IVANOV 1957, 211-232 for the excavations at *Germania* and the known data for this settlement. For the tubes, see IVANOV 1957, 223-224.

[53] See IVANOV 1957, 223-224. For the fortress at Hisarlaka, see for instance KATSAROVA 2005, 134-135; DINTCHEV 2006, 35; for the archaeological investigations near Kadin most, see IVANOV 1910, 163-201; for the site at near the same village, identified as a large Roman villa of the 1st – 4th c. AD, see also DINCHEV 1997, 83; KATSAROVA 2005, 176-177.

[54] KULOV 2007, 132-142; for the site and its function, see also HARIZANOV 2020, 116.

Table 3. Dimensions of vaulting tubes and vaulting pots from sites in Bulgaria, mentioned in the text (based on examples with entirely preserved body parts).

Dimensions → (min. – max., in cm) Site of discovery ↓	Overall height	Body height	Nozzle height	Body thickness	Nozzle thickness	Shoulders diameter	Body inner diameter (bottom)	Nozzle upper (outer) diameter	Nozzle lower (outer) diameter
Novae	42.4	27.5-29.2	13	2.4-4	0.7-1.2	16-19.5	11-13	5.2	10.5-12.8
Byala	18.2	-	-	1.3-2	-	14.2	-	-	-
Serdica	26.5	17	9.5	?	?	15	?	4	?
Germania	17	10	7	?	?	11.5	?	5.2	5.2
Poleto	28.3/38.4	20.2/32.8	8.1/5.6	1.7-2.4	1.3-1.8	11/9.6	10/8.5	6.5/6.1	8.3/6.8

nozzles, with wheel-made grooves visible mostly on the inside. One of the finds is much longer than the others, however with similar shape and diameters of the body and nozzle[55].

According to the researcher, the site has functioned as a production centre for lime and ceramic building material for the nearby Roman village. In concordance with the discovered pottery and coins (of which three were identified – of Septimius Severus, Gordian III and Claudius II), it was dated to the late 2nd – 3rd c. AD[56]. Furthermore, the presence of large amount of fragmented domestic pottery at this site, apart from its usual household context, led to the hypothesis that it was likewise produced on the spot, along with the other construction materials discovered[57].

4. Purpose of the Moshtanets vaulting tubes

In view of the dated examples of vaulting tubes described so far and places of their application (both in the Balkans and the rest of the Empire), the assemblage examined here was most likely intended for the construction of a bath building. Such a designation fits well into the chronological distribution of the nozzle tubes in the period in question (late 3rd – early 4th c. AD), when the Moshtanets workshop was supposedly active. Of similar use were the vaulting tubes in *Novae*, *Oescus*, Madara (here of different shape), *Sirmium*, *Viminacium*, *Timacum Minus*, etc. The examples from *Serdica* and *Germania* come from contexts not securely identified, but most likely also public buildings, while those from *Scretisca* were found reused, outside their original context. Nothing could be said about the supposed tube finds from Hisarlaka and Kadin most.

No bath building (or other structure with at least partly preserved vaulted ceiling) was discovered during the excavations of the Moshtanets site, which however does not exclude the possibility of the presence of such a construction in the unstudied part of the Late Roman village.

In 2017 and 2018 another Roman and Late Roman settlement was discovered on the road bed of the Struma Highway, just several km to the North of Moshtanets, near the neighbouring modern village of Pokrovnik. The site in question was identified as a Roman and Late Roman *villa* (3rd to mid- 5th c. AD) with adjacent *vicus* (second half of the 2nd / 3rd c. – 4th c. AD). Within the Late Roman villa complex (late 3rd – mid- 5th c. AD) a small bath was found, however without any indications for the use of vaulting tubes. Furthermore, about a dozen ceramic kilns were unearthed within the *villa* and the *vicus* areas, most likely used during the 3rd and the 4th c. AD[58]. No traces of vaulting tubes (or vaulting pots for that matter) were found among their ruins[59].

Given that both *Pautalia* and *Germania* were situated near mineral water deposits, which were exploited during the Roman and Late Roman periods (and are still in use today)[60], it could be suggested that the output of the Moshtanets workshop was directed towards thermal construction projects in one of the two towns[61]. However, the distance among the three centres[62], along with the presumed limited output of the ceramic workshop in question[63], could make other possibilities for local distribution of its products to be more plausible. In this context, one cannot exclude the Roman settlement of *Scaptopara*, already mentioned (but known from an inscription of earlier date), which was most likely located much closer to Moshtanets[64] and at the same time situated near mineral water deposits, while its baths were used by both indigenous people and travellers coming to

[55] See dimensions (taken by the available drawings from the original publication) in Table 3.
[56] See KULOV 2007, 134-135; 139-140.
[57] HARIZANOV 2020, 116.
[58] For the archaeological research and the dating of the site, see DIMITROV/RAYCHEVA/RUSEV 2019, 380-382; DIMITROV 2019, 1-16. For the ceramic kilns, see HARIZANOV 2020, 110-111.
[59] I was able to participate in the research of more than half of the ceramic kilns and observe that of the rest. In addition, the lack of vaulting tubes among the ceramic material from the site's research was confirmed by Dr. Nikolay Rusev (Deputy Dig Director of the excavations), to whom I express my gratitude.
[60] For the baths at *Pautalia*, see KATSAROVA 2005, 118-125; regarding *Germania*, the name of which derived from the Thracian words for "hot spring", see STAYKOVA-ALEKSANDROVA/STAYKOVA 2003, 202-214.
[61] It should be noted that apart from the mentioned finds from *Germania*, I was unable to find any other mention of vaulting tubes in the available publications, concerning the two towns and their architectural remains.
[62] About 48 km in a bee line between Moshtanets and *Pautalia*, and 40 km in the same measure between Moshtanets and *Germania*, and even more following the routes of the Roman roads (distances measured in Google Earth).
[63] With about 90-120 tubes per firing, a month's output of this single kiln (assuming there were no other installations in the unexcavated parts of the village) could have reached numbers between 540 and 1200 tubes (six to ten firings a month, i.e. one firing every three to five days). A larger output seems doubtful, having in mind that it almost certainly would have resulted in building a bigger kiln, which would have allowed for significant increase of the workshop's production capacity.
[64] For the possible locations of *Scaptopara*, see for example KATSAROVA 2005, 196-197. One of the proposed locations is underneath the modern neighbourhood of Gramada in Blagoevgrad, some 5 km to the North of Moshtanets, on the left bank of the Struma River.

the nearby trade fair[65]. It could likewise be hypothesised that the vaulting tubes were produced for a private building, for example situated in the estate of one of the local landlords. To conclude, smaller sized buildings from the nearby region (private or public *balnea*, or other ceiled constructions of limited size) are the much more probable recipients of these products[66].

For the moment, the reason for the deposition of the batch of tubes inside their place of discovery also remains unclear. Although some of the finds show slight traces of mortar on their outer surfaces, the lack of such on the inside indicates that they had not been used properly and that these remnants of plaster are likely owed to debris from the rest of the deposit or from the ruins of the building.

CONCLUSION

Advancement in the study of vaulting tubes within the boundaries of the Empire in recent years is bringing us closer to discovering the actual range of their spread and use during the Roman and Late Antique periods. Although many controversies in relation to the nature of their distribution patterns remain, what seems certain is that there was an export of know-how, either directly from the North African area or also indirectly via other economically active provinces to other developing Roman territories. In view of the latter, the appearance of vaulting tubes in *Dacia Mediterranea* during the late 3rd and the 4th c. AD, both in construction contexts and as presumable local products, comes as no surprise, since it coincides with the emergence of the zone of the dioceses of *Thracia*, *Dacia* and *Macedonia* under the Tetrarchy and the Constantine dynasty, when this region became a background for major political events, economic reorganisations and grand architectural projects.

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[65] The nature of the appeal of the inhabitants of *Scaptopara* to the Emperor was precisely the abuse of the locals by government officials and soldiers coming to the fair, who among other things used their bath facilities without payment (see GEROV 1988, 169-170; SHARANKOV 2012, 528-533).

[66] If the nozzle tubes were placed inside one another with an inclination of about 5 degrees, 36 or 37 tubes would have been needed for the erection of a 4 m wide, 2 m high arch (see example in Fig. 18). Therefore, a little over 1400 tubes would have been required for the construction of a barrel vault, covering 6 m long and 4 m wide room (24 m^2). Based on the calculations for the capacity of the Moshtanets kiln, such amount of tubes could have been fired there in a little over a month.

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Fig. 5. Photo of the ceramic kiln: initial stage of research (author G. Grozdanova).

Fig. 6. Photo of the ceramic kiln after the removal of the upper layer of the perforated floor (author A. Harizanov).

Fig. 7. Photo of the ceramic kiln: view from above of the lower layer of the perforated floor (author A. Harizanov)

Fig. 8. Photo of the ceramic kiln: view from above of the combustion chamber and the supporting pillar (author A. Harizanov)

Fig. 9. Photo of the ceramic kiln: final stage of research (author A. Harizanov)

Fig. 10. The ceramic tubes from Moshtanets (photo A. Harizanov).

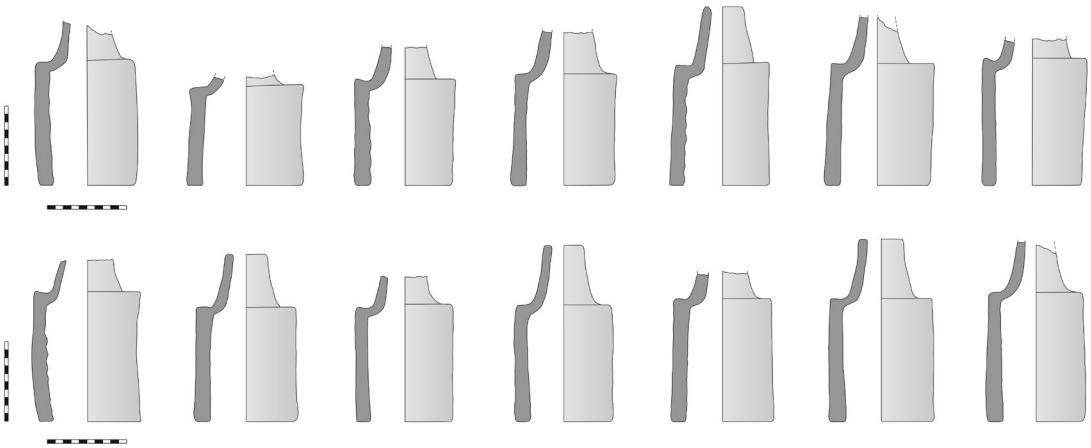

Fig. 11. The ceramic tubes from Moshtanets: drawings of type I (authors K. Koseva, A. Harizanov).

Fig. 12. The ceramic tubes from Moshtanets: photo of examples of type I (author A. Harizanov).

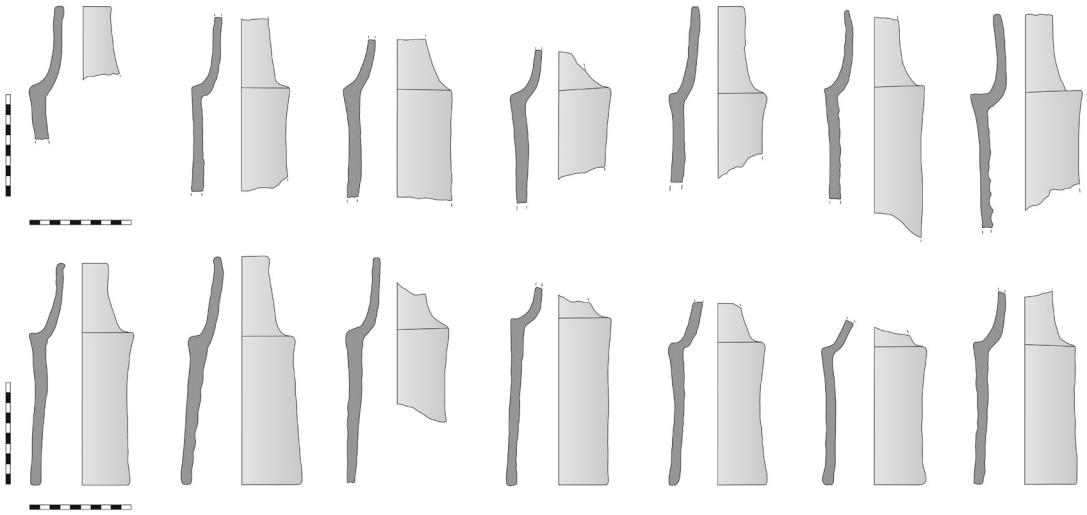

Fig. 13. The ceramic tubes from Moshtanets: drawings of type II (authors K. Koseva, A. Harizanov).

Fig. 14. The ceramic tubes from Moshtanets: photos of example of type II (author A. Harizanov).

Fig. 16. The ceramic tubes from Moshtanets: photos of an overfired example of type I (author A. Harizanov).

Fig. 15. The ceramic tubes from Moshtanets: photo of examples of type II (author A. Harizanov).

Fig. 17. The ceramic tubes from Moshtanets: drawing and photo of a production waste (authors K. Koseva, A. Harizanov).

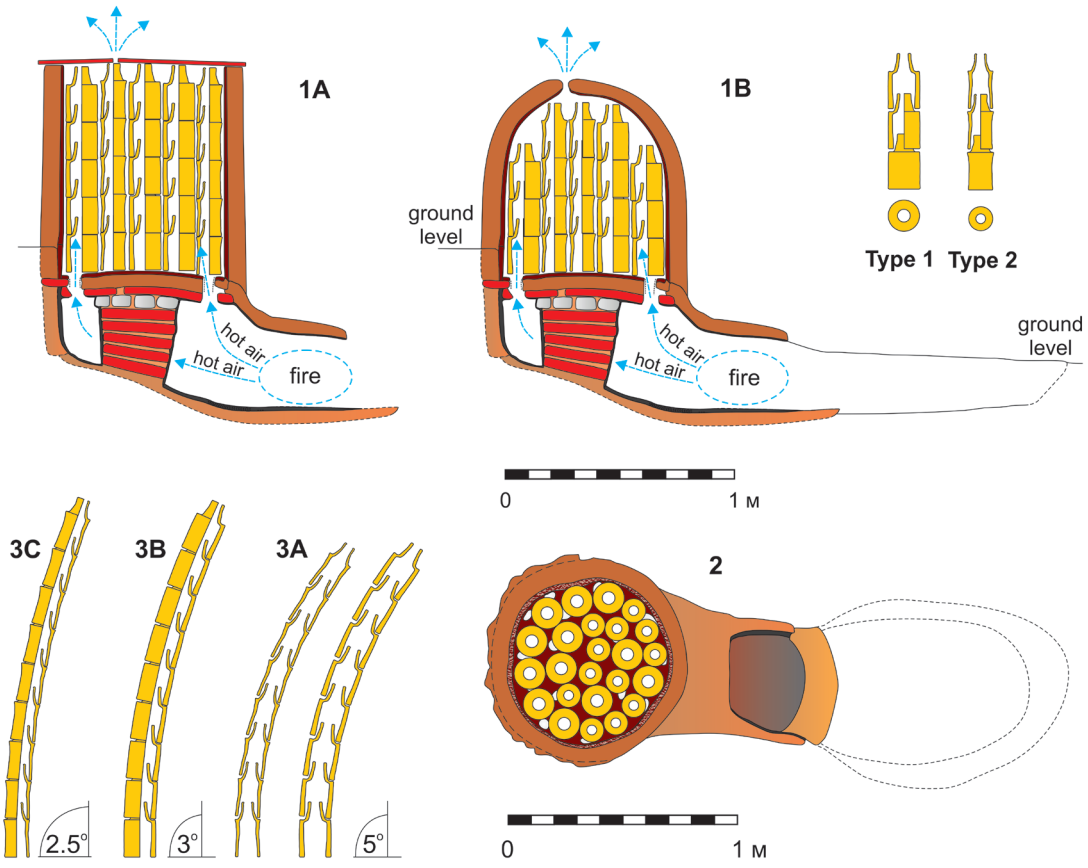

Fig. 18. Graphic reconstruction of liable stacking arrangements of the vaulting tubes inside the kiln's firing chamber and possible setups of tube vaults (author A. Harizanov)

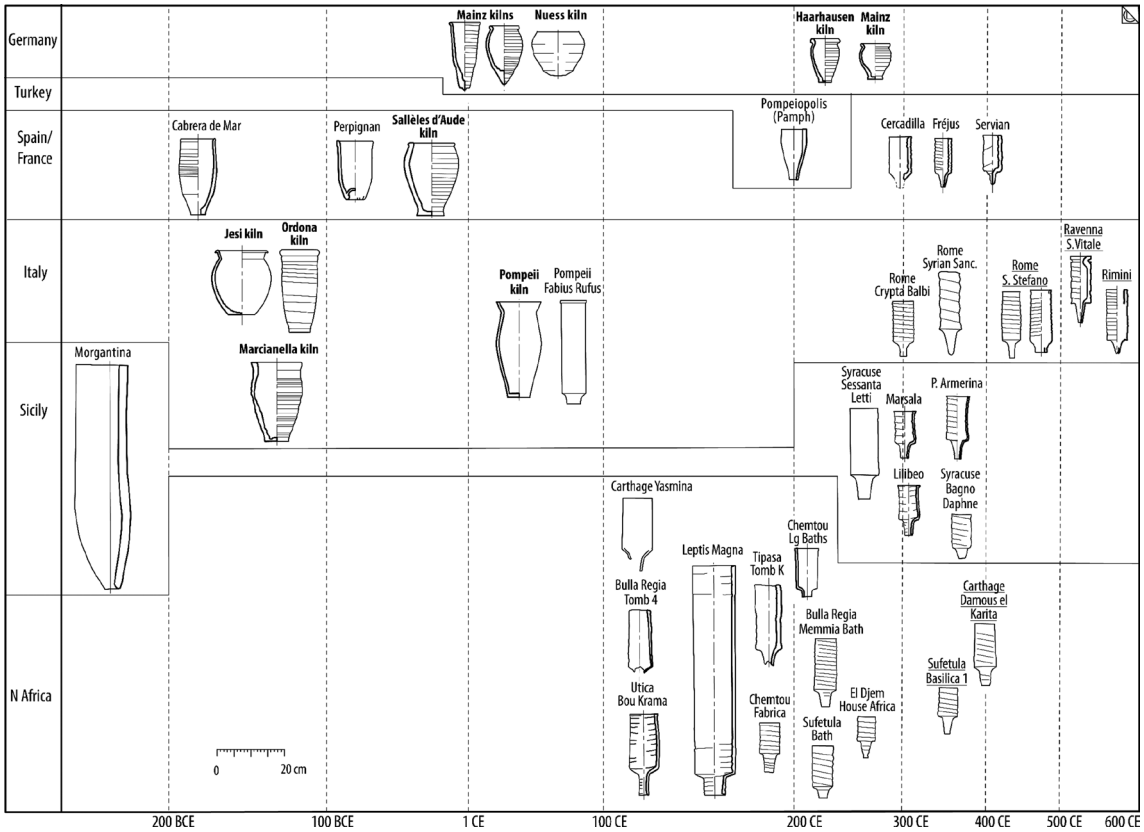

Fig. 19. Typological and chronological chart of vaulting tubes and vaulting pots (after LANCASTER 2015, 103, Fig. 68).

Fig. 20. Vaulting tubes from the legionary baths at *Novae* (after BIERNACKI 2016, 79, Tabl. VI; digital remastering and corrections by A. Harizanov).

Fig. 21. Possible vaulting pot from the kiln at Byala (photos and drawing by Valeri Yotov).

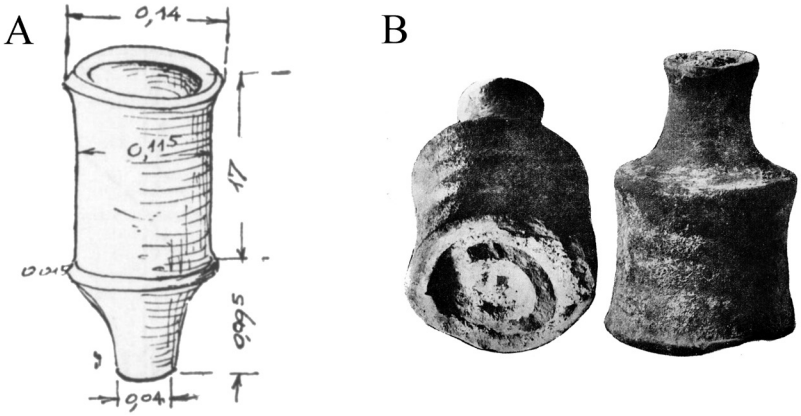

Fig. 22. Vaulting tubes from *Serdica* /A/ and *Germania* /B/ (after BOBCHEV 1955, 212, Fig. 7; IVANOV 1957, 223, Fig. 14).

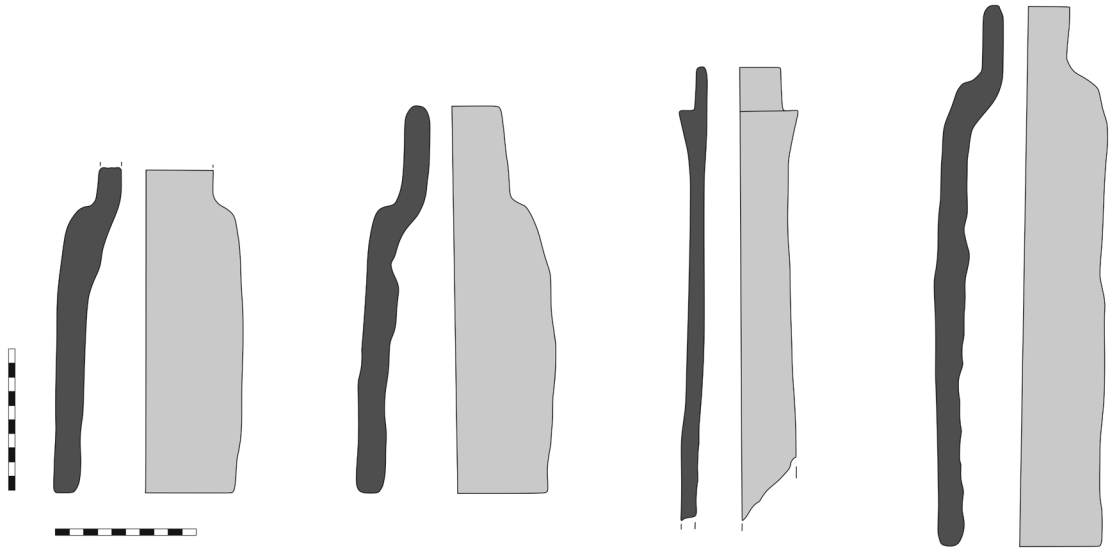

Fig. 23. Tubes from the site at Poleto, Simitli district (after KULOV 2007, 136, Fig. 9; digital remastering by A. Harizanov).