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WALL HEATING SYSTEMS IN ROMAN ARCHITECTURE AND 'SPACER TUBES' FOUND IN THE PARION SLOPE STRUCTURE

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Parion is situated in the village of Kemer, and is connected to the town of Balıklı Çeşme, in the Biga District of Çanakkale. The city was established around a stream that flows into the sea and has a natural harbor, as have other colonial cities established in the region during the 7th and 8th centuries BC. Excavations were carried out from 2008 until now, in a building with rooms of different sizes, walls, water channels, mosaic pieces, glass products, ceramic pieces from different periods, and many bronze coins in poor condition. In addition, excavations conducted on the northern side of the structure showed the remains of a cylindrical ground support with pilae*, which belong to a 'hypocaust system'. This article discusses the ways in which* caldarium *and* tepidarium *rooms from Early Roman to Byzantine period bathhouses and villas were provided in that period of time with a hypocaust wall heating system. One of the new construction methods is the use of 'spacer tubes': small hollow terracotta tubes which were used during a long time because they were cheaper. In Parion, one of the most important cities of Troas Region in the Roman period, the excavated small building showed three building phases. The spacer tubes have revealed new information of their building function. They are very important as there are only few examples of this building method in the Troas region. Examples of their types and features are described in a catalogue.*

Location and Foundation

Parion is located on the Anatolian side of the Propontis (Sea of Marmara) region, including the Biga Peninsula, in the west of Anatolian Turkey. Parion is situated in Kemer Village, connected to the town of Balıklı Çeşme, in the Biga District of Çanakkale (Fig. 1).

Parion is located at Bodrum Burnu (Cape Bodrum). The city was founded at both sides of a river where it empties into the sea and has a natural harbor, very much like other colonies established in the region during the 7th and 8th centuries BC. Although there is no definitive information about the foundation of Parion, Strabo (Str. 13.1.14) reports that the foundation of the city, which might be dated

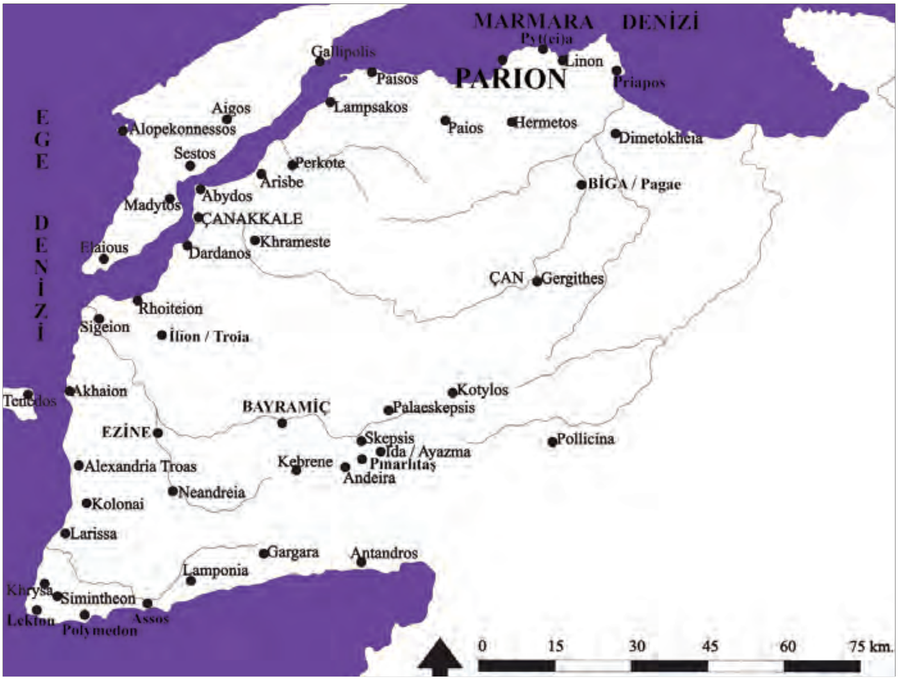

Fig. 1. Troas Region and Parion.

to 709 BC, might, amongst others, be related to the colonization by the city of Miletus, Erythrai, and Paros. In addition to these sources, Pausanias (Paus. 9.27.1) indicates that Parion was colonised by the city of Erythrai (Çelikbaş 2010, 10).

Modern research partially confirms the information provided by historical sources. Both modern and historical sources indicate that three cities may be taken as the founders of Parion: Erythrai, Paros (Keleş 2011, 238-239), and Miletus (Tsetskhladze/Hargrave 2010, 396). There is a strong discussion about the role of Erythrai on the names of Oikists (= founders) and this discussion may stem from the fact that the names of some people came to light. Gorman (2001, 245) concludes that Paros was highly influential and likely to be the origin for the name of Parion. The city of Miletus was known as the founder of many colonies in the region (Keleş 2003, 5; Tekin 2008, 70). However, the only information on this issue is provided by ancient literary sources, as the excavation of Parion is currently in its initial stage, and no new archaeological evidence has yet been discovered (Çelikbaş 2010, 10).

In 2004, groundwork started in the area of (what would become) the South Necropolis of the ancient city, in preparation of the construction of an elementary school, and subsequently graves and archaeological materials were uncovered

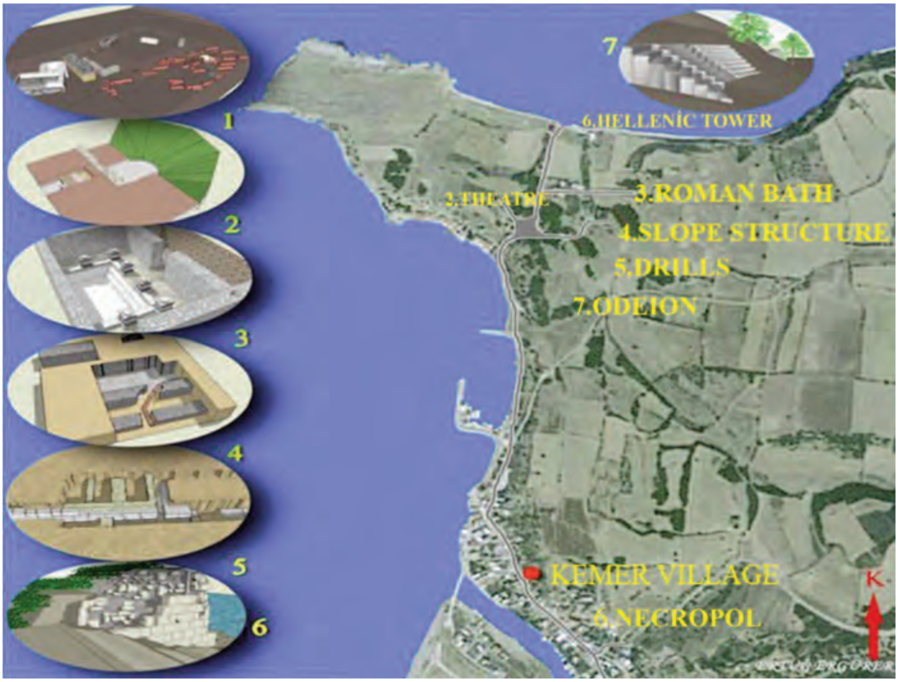

Fig. 2. Parion, Excavation Sectors.

dating to Antiquity. Upon this development (Başaran 2006, 26–28), rescue excavations were carried out in the area of the necropolis by the Archaeological Museum of Çanakkale in the same year (Kozanlı 2006, 28). In 2005, however, systematic excavations were carried out in the ancient city for the first time by a team under the leadership of Prof. Dr. Cevat Başaran, who previously already had conducted archaeological surface research in the region between 1999 and 2002 (Başaran 2005, 20-22). Systematic excavations were carried out at 6 locations [in Fig. 2:7] within the city over a five-year period. The sectors in which these excavations were carried out are shown in Fig. 2 as: Theatre, SDJ 1, Roman Bath, South Necropolis, Odeion, and the Slope Structure. These excavations form the basis of the present report.

The Slope Structure

Excavation works (initiated in 2008) are ongoing to the east of the Parion Acropolis and the ancient theatre, within a sector located on the western slope of a hill (Figs 3-9). Excavations were carried out between 2008 and 2011, in a building with rooms of different sizes, walls, water channels, mosaic pieces, glass products, ceramic pieces from different periods, and many bronze coins in poor condition. In addition, works conducted on the northern side of the structure identified the

Fig. 3. Parion, Slope Structure.

remains of a foundation consisting of cylindrical *pilae*, which belong to a 'hypocaust system'. In 2009, elements of a three-wall heating system, called a 'Spacer Tube', which is the subject of the present report, were found in a range of about 250-300 cm outside the part having a hypocaust (Başaran 2010, 289).

Roman Heating Systems

The popularity and spread of bathing in the Roman world was directly related to the technological developments associated with baths. In particular, the devel-

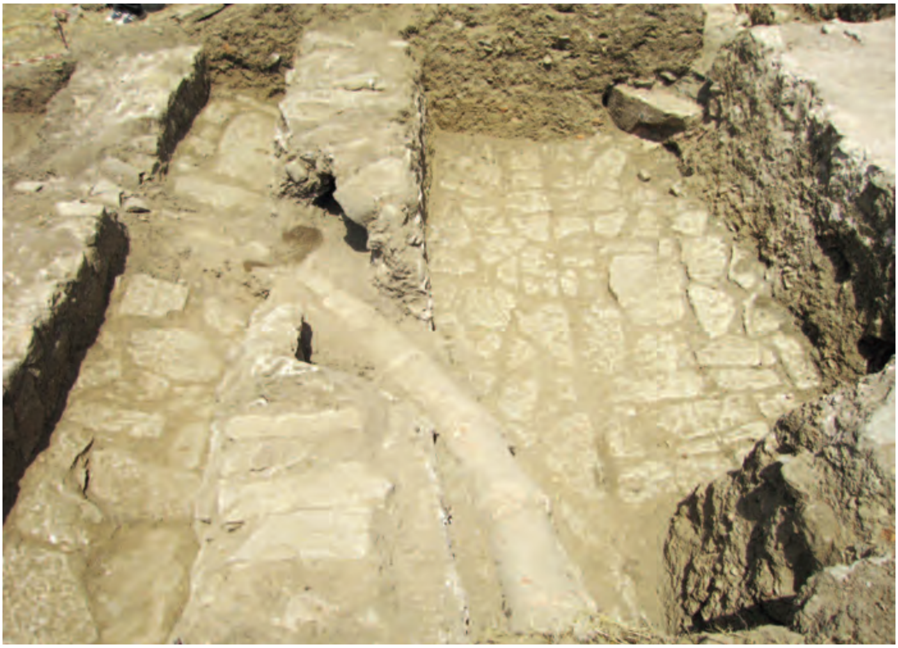

Fig. 4. Parion, Slope Structure, Water Supply.

Fig. 5. Parion, Slope Structure, Water Supply, Detail.

Fig. 6. Parion, Slope Structure, Water Channel.

Fig. 7. Parion, Slope Structure, “Twin Pool”.

opment of a hypocaust system for under-floor heating, dating to the end of the 2nd century BC, constitutes the real reason for the spread of this bathing habit. It is accepted that the hypocaust system and its simpler derivatives were independently developed in the city of Olympia in Greece (Winter 2006, 133), and in the city of Pompeii in Italy (Rook 1992, 12). Moreover, the Romans pioneered the systematic use of hypocaust systems in bath design for controlling heating temperature (Yegül 2006, 16). The Roman merchant and hydraulic engineer Sergius Orata, who invented ‘*Balnea Pensiles* (= hanging baths)’ in the 1st century BC, was the first person to present an under-floor heating system, that is to say a hypocaust system, in practice (Nielsen 1993, 21–22; Fagan, 2002, 98). The use of the walls and the floor to function as heating elements provided more effective space-heating and more effective re-use of hot gases of the hypocaust (Chant/Goodman 1999, 104). Wall heating was implemented through four architectural elements: ‘*tegulae mammatae*’ (sc. tiles with four perforated conical lugs on one side close to their corners), ‘*tubuli*’ (sc. hollow rectangular tubes), ‘spacer pins’, and ‘spacer tubes’ (Wright 2005, 131). A wall heating system was found for the first time in the 1st century BC in the *caldarium* (sc. a hot room, heated and with a hot-water pool and a separate basin on a stand (‘*labrum*’)) and the ‘*tepidarium*’ (sc. a warm room, indirectly heated and with a tepid pool) of

Fig. 8. Parion, Slope Structure, Hypocaust System.
Fig. 9. Parion, Slope Structure, Hypocaust System Basement.

the Stabian Baths and in the '*caldarium*' of the Forum Baths in Pompeii (Mau 1982, 205-206; Chant/Goodman 1999, 104). These systems are explained briefly.

Tegulae Mammatae

Tegulae mammatae is the general name of terracotta ceramic wall-tiles, which are large, square-shaped and have on one side of the tile protruding conical lugs at their edges (Yegül 2006, 16) **(**Fig. 10**).** These tiles were placed on the interior face of a wall, and attached with "T" shaped clips, nails, and terracotta cylinder pillars by inserting them into mortar or stone with their sharp sides (Rook 1978, 270). Thus, the protruding spacers on the tiles produced an air-gap between the wall and the tiles, permitting the circulation of hot air for a wall heating system (Rook 1992, 14). We learn from Vitruvius that this application was also used to provide isolation against moisture in internal walls (Vitr. 7.4.1-2).

Tubuli

Next to the use of the *tegulae mammatae*, a brick system called '*tubuli*' – hollow bricks that were made of terracotta – was developed, and placed between the wall and the flagstones (Meikleham 1845, 42–43) **(**Fig. 11**).** The *tubuli* served as a chimney, but were also used in the construction of the wall heating system (Rook 2002, 16). *Tubuli* have an internal wall with a thickness of 2 cm and are approximately 25×15 cm in size (Nielsen 1993, 15; Coşkun 2004, 59). They are placed in the walls of the structure by means of a clamp and mortar (Rook 2002, 16) and their surface is covered with stucco, gatch (i.e. a type of plaster used by Persian craftsmen), and marble (Adam 1994, fig. 629). The mouths of *tubuli* opened to a hypocaust system at the bottom and to a chimney at the top. In this way, hot air exiting from the hypocaust heats the walls by passing through the *tubuli* placed side-by-side and stacked on top of each other, and is emitted through the chimney (Forbes 1966, 54–56). The *tubuli* system was first used in the walls of the house of Julia Felix in Pompeii, together with *tegulae mammatae* (Rook 2002, 16). The *tubuli* system, which is more difficult to place inside the wall than the *tegulae mammatae*, was generally predominantly used in the baths of the Empire period (Adam 1994, 629–630).

Spacer Pin

The 'Spacer pin' system was developed as an alternative to *tegulae mammatae* and *tubuli*; it consists of a terracotta nail that has a length of 20–25 cm and a head with two disk-shaped, round asperities and a tapering block (Farrington/Coulton 1990, 56–57) **(**Fig. 12**).** In the head part of the nail, which resembles a disk, there is one slot on which one edge of terracotta plates can rest. The other end of the spacer pin is inserted into beds opened in the masonry and arranged as a polygon, generally a rectangular shape (Korkut 2003, Abb. 6; Farrington/Coulton 1990, fig. 3). Spacer pins are mounted to the wall by means of mortar. Yegül (2006, 94, Fig. 84) suggested that spacer pins were inserted into the joints of walls. However, since it is necessary to mount spacer pins to a wall in a symmetric way

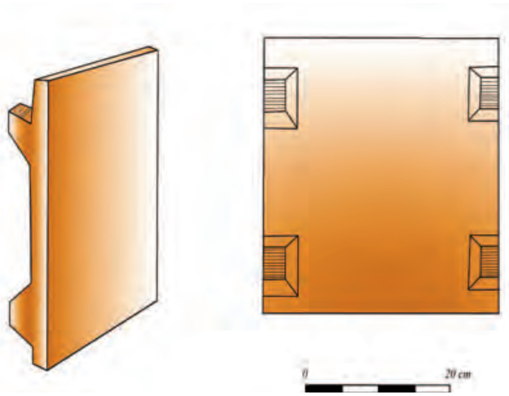

Fig. 10

Fig. 11

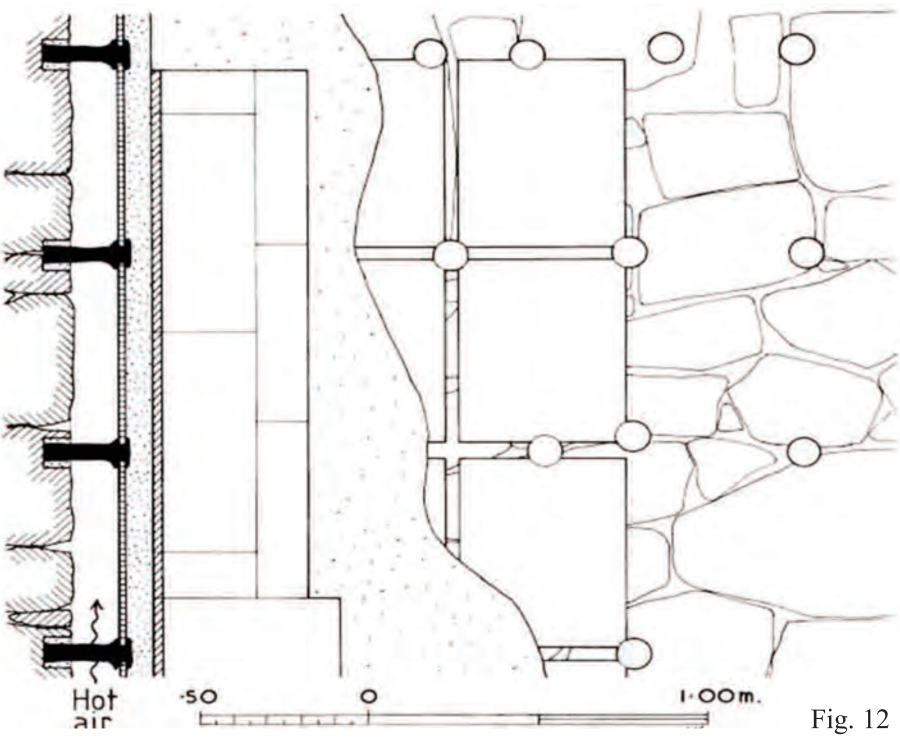

Fig. 12

Fig. 10. Tegulae Mammatae System.
Fig. 11. Tubuli System.
Fig. 12. Spacer Pin System (Farrington-Coulton 1990, Fig.4).

at certain intervals, they are mounted not only in the joints of the wall, as previously suggested, but also in the holes which open to the stones. The surface of the terracotta plates, which were placed in the slots of spacer pins, was covered with stucco/mortar, it was then covered with marble plates. There is no definitive information regarding when the spacer pin system was first used in baths. Yegül (2006, 94) states that the spacer pin system was mostly seen in the Mediterranean and Anatolia, while Farrington (Farrington 1995, 101–104) indicates that it was used in the baths of the Lycia region in particular.

Spacer Tube

The last of the terracotta architectural heating-elements discussed in this article are called 'spacer tubes' **(**Figs. 13-14). In contrast to the nail-shaped spacer pin design, spacer tubes were conical (9 to 15 cm), disk-shaped elements with two open mouths, provided with lips that were twisted towards the outside. In the spacer tube system, spacers were nailed to the wall with cylinder or T-headed iron nails (Fig. 13: pins) in a way that terracotta plates could be attached. This created a space of 10-15 cm between the wall and the terracotta plates, through which hot air could circulate **(**Fig. 13).

The cavities of the spacer tubes, which are claimed by Farrington to have been produced as an alternative to *tegulae mammatae* (Farrington/Coulton 1990, 64–65), can be broader than the nails passing through them. In order to make the spacers stronger, their inner parts were probably filled with mortar (Fig. 13) when they were nailed to the wall.

It is necessary to ask why the spacer tube system was preferred when the *tubuli* design was the strongest and the most successful of the wall-heating systems; probably the reason was economic[1]. Spacer tubes, which are generally seen in bath buildings belonging to the Late Roman–Early Byzantine periods (Biers 2003, 311), have the lowest production costs of the wall-heating systems, taking into consideration the economic conditions of the period. The traces of throwing-rings on the excavated spacer tubes indicate that these were produced using a potter's wheel. The fact that they have a simple form, and the small quantity of ceramic clay needed for their manufacture, might well suggest basic economic cuttings as the reason for their use in the wall-heating system.

It is observed that, apart from economics, the spacer tube system provides some additional advantages compared to the other systems. The width of the *tubuli* was greater than that of the spacer tubes. This means that a much greater volume of hot air could pass through the *tubuli*. When more hot air was needed, much more fuel was consumed. However, because the spacer tubes only allowed for a

[1] The Roman Empire suffered from military crises, domestic instability, and political and social transformation in the 3rd century AD. This transformation not only affected the basic central economy but also resulted in an economic crisis in the provinces. The crisis is clearly demonstrated by the fact that the proportion of silver in coins was reduced to 2% between AD 260 and 268. See Howgego 1998, 156–160.

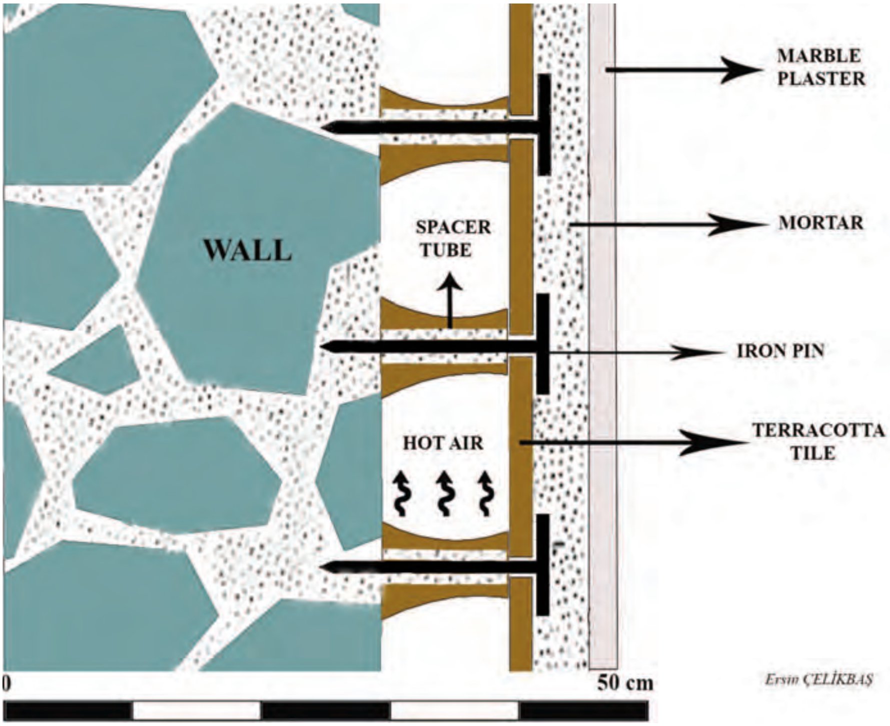

Fig. 13. Parion, “Spacer Tube” System.

Fig. 14. Parion, Slope Structure, Spacer Tubes.

much more limited space compared to the *tubuli*, less hot air and thus less fuel was needed (Farrington/Coulton 1990, 66). However, as mentioned above, the *tubuli* had an internal wall-thickness of 2 cm. The heat must pass through the 2-cm thick *tubuli* layer before reaching the adjoining wall. As terracotta has a lower thermal retention than the masonry wall, this again introduces additional costs in terms of fuel consumption. However, as there is no layer between the spacer tube and the adjoining wall, the hot air is in direct contact with the wall of the building. As a result, the wall retains heat longer and thus provides fuel saving.

It is also interesting to consider why the spacer tube system was developed as an alternative to the spacer pin system, which was similarly cheap to produce, and which was as successful as the *tubuli* in creating the required space for ventilation. The answer is hidden in the difficulties encountered in mounting the spacer pin system. As mentioned above, the spacer pins were mounted symmetrically, on the surface of a wall, at specific intervals. This required the lengthy preparation of appropriate mounting holes in the wall, thereby increasing the construction cost of the building. However, there is no symmetry in spacer tubes and spacers are generally nailed into the mortar between the stones, thereby reducing the cost of constructing the building. This clearly demonstrates why spacer tubes were adopted as an alternative to spacer pins. In addition, much more ceramic clay was used in the production of spacer pins than in that of spacer tubes. Another disadvantage of spacer pins is their required space for lugs. It was necessary to produce terracotta plates with lugs in order to make the spacer pin fit in the slots located at the top of the disks. This resulted in the need for the molding of the terracotta plates, which is not required for spacer tubes (Farrington/Coulton 1990, 65-66). Taking all of these reasons into consideration, it is clear why spacer tubes were developed as an alternative to spacer pins.

The spacer tubes show regional variations and do not have standard forms or patterns (Cunliffe 1976, 31). There are spaces through which a nail can pass. Some of the examples excavated in Parion have wider spaces through which a nail can pass. In addition, there are no patterns on them, but only some traces, which can be observed both internally and externally, indicating that they had been produced on a potter's wheel.

It is important that they had the same function as their antecedents. The fact that spacer tubes were developed as an alternative to the previous wall-heating systems is, perhaps, a consequence of economic conditions. Spacer tubes were preferred to previous versions, which were more expensive due to changes in the plans and sizes of baths from the Late Roman – Early Byzantine period[2]. The finds of spacer tubes in the city of Parion is of great significance. Studies indicate that the city of Parion has been permanently settled since its foundation in 709 BC. This makes it possible that these architectural elements, first emerged in Parion, located in the Troas region.

The fact that late-period technology emerged in Parion contemporaneously with other cities demonstrates that the builders of this construction in Parion may possibly have been aware of new technologies in the late Roman period, and that there was widespread communication and technological diffusion throughout the Empire. Along with the regions of Phrygia, Paphlagonia, and Kilikia where spacer tubes are seen in Anatolia, Parion, located in the Troas region[3], is the only ancient city in which late-period wall-heating systems emerged.

We do not yet have conclusive information about the structure from which spacer tubes emerged. The spacer tubes were not found *in situ* (on a wall), and the material may have originated on a different level, because the excavation site is located on a slope; this makes it difficult for us to comment on the structure. As spacer tubes are generally seen in parts of baths and villa complexes with a hypocaust system, the available information suggests that the Slope Structure was a bath complex.

CATALOG

Floor No.	: 1
Figure No.	: 14
Name	: Spacer Tube
Material	: Terracotta
Location of excavation	: The Slope Structure
Height	: 9.9 cm
Mouth Diameter	: 4.9 cm
Floor Diameter	: 7.5 cm
Dough Color	: Munsell: 2.5 YR 5/6
Plaster Color	: Munsell: 2.5 YR 5/8
Clay	: Graded
Additive	: Many stones, limestone at mid level, small amount of mica
Fabric	: Hard

[2] Related to the economic crisis in the Late Roman–Early Byzantine period, it became increasingly expensive to operate great public baths, maintain the building, and pay employee salaries. In addition, the constant need for fuel to heat rooms and provide hot water became an important problem. Furthermore, problems emerged in relation to water resources. As a result, it can be accepted that smaller 'balnea' became preferred to the baths in the Late Roman–Early Byzantine period, which were large and difficult to operate. Such smaller balnea were not only more economical to operate, but were much more easily constructed within the city because they required less ground surface. Since there were much more customers in the city, such operations had much greater economic viability (see Koçyiğit, 2006, 119; Steskal, 2011, 90).

[3] The graves excavated in the South Necropolis show that, in terms of typology and burial traditions, the ancient city of Parion reflects the traditions of the Troas region rather than that of the Mysia region, indicating that Parion was associated with the Troas region (see Başaran 2005, 20–22).

Burning	: Good
Surface Quality	: Dusty, ragged
Construction Technique	: Thrown
Mesh	: Mid-Range
Definition	: The form tapers from the floor to the mouth. There are traces (internally and externally) from being formed on a potter's wheel
Construction	: Potter's wheel
References	: Biers 1985, Cat. No: 113-115; Haalebos/Thijssen 1977, Fig. 7: 1-4; Sanders 1999, Fig. 17, 25-26; Koçyiğit 2006, Cat. No. 1-8.
Date	: Late Roman – Early Byzantine

Floor No.	: 2
Figure No.	: 14
Name	: Spacer Tube
Material	: Terracotta
Location of excavation	: The Slope Structure
Height	: 9.2 cm
Mouth Diameter	: 4.9 cm
Floor Diameter	: 7.5 cm
Dough Color	: Munsell: 2.5 YR 5/6
Plaster Color	: Munsell: 2.5 YR 5/6
Clay	: Graded
Additive	: Plenty of stones, limestone at mid-level, small amount of mica
Fabric	: Hard
Burning	: Good
Surface Quality	: Dusty ragged
Construction Technique	: Thrown
Mesh	: Mid range
Definition	: The form tapers from the floor to the mouth. There are traces (internally and externally) from being formed on a potter's wheel
Construction	: Potter's wheel
References	: Biers 1985, Cat. No. 113-115; Haalebos/Thijssen 1977, Fig. 7: 1-4; Sanders 1999, Fig. 17, 25–26; Koçyiğit 2006, Cat. No. 1-8.
Date	: Late Roman – Early Byzantine

Floor No.	: 3
Figure No.	: 14
Name	: Spacer Tube
Material	: Terracotta
Location of excavation	: The Slope Structure
Height	: 9 cm
Mouth Diameter	: 4.7 cm
Floor Diameter	: 7.3 cm
Dough Color	: Munsell: 2.5 YR 5/8
Plaster Color	: Munsell: 3.5 YR 4/6
Clay	: Graded
Additive	: Plenty of stone, limestone at mid-level, small amount of mica.
Fabric	: Hard
Burning	: Good
Surface Quality	: Dusty ragged
Construction Technique	: Thrown
Mesh	: Over
Definition	: The form tapers from the floor to the mouth. There are traces (internally and externally) from being formed on a potter's wheel
Construction	: Potter's wheel
References	: Biers 1985, Cat. No: 113–115; Haalebos-Thijssen 1977, Fig. 7: 1–4; Sanders 1999, Fig. 17, 25–26; Koçyiğit 2006, Cat. No. 1–8
Date	: Late Roman–Early Byzantine

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