On Water Supply System in Ancient Armenia

Aminia Kanetsyan

National University of Architecture and Construction of Armenia,
105 Teryan Street, Yerevan, Republic of Armenia

amina-kanetsyan@mail.ru

Keywords: water supply, drainage system, pottery Kiln, water parting nodes, water reservoir.

Abstract. Based on the excavations of the ancient capital of Armenia, Artashat (2nd century BC - 5th century AD), and the ancient fortress of Garni (1st-3rd centuries AD), the problems of the public water supply system of cities on the territory of Armenia were studied. Centralized water supply in the territory of Armenia can be traced back to the Urartian times (IX - VI centuries BC). Later, in the Hellenistic period, the water supply system of cities was improved. So, on the territory of the Garni fortress, a water supply system with wide branching was opened, which supplied water to the entire territory of the fortress. It was a canal dug into the ground, for the construction of which hydraulic mortar was used. From above, the channels were covered with untreated basalt slabs, connected to the sides of the channel with lime mortar. In Artashat, the same canals were found used for drainage, while water was supplied through pottery pipes. Found in a large number of pottery pipes were of various sizes. In the construction of the water basin discovered in Artashat, waterproof concrete with reed reinforcement was used.

Introduction

The history of artificial water supply to cities has a very ancient tradition dating back to the third millennium BC. By this time, in the countries of the Ancient East, a centralized system of water supply to cities with open canals and their ramifications appeared.

The construction of centralized water supply to cities on the territory of ancient Armenia can be traced back to the Urartian time. The discovered cuneiform inscriptions inform about the construction of water canals to many Urartian cities and settlements [1]. Thus, excavations in the Urartian city of Argishtikhinili revealed a water conduit cut in the stone ground and lined with stones (Fig. 1). In the Urartian city of Erebuni, well-processed tuff stone pipes were found from the pipeline through which drinking water was delivered to the citadel of the city (Fig. 2).

Fig. 1. Water canal of Argishtikhinili

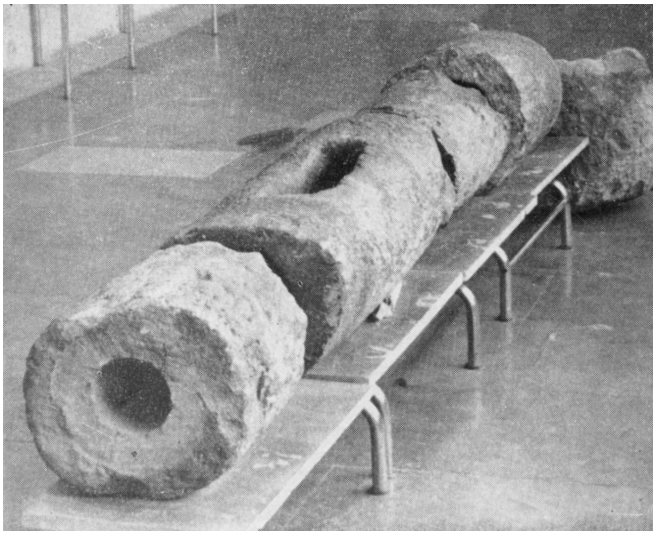

Fig. 2. Stone pipes in Erebuni

The excavation architect believed that water was supplied from the Garni mountains [2]. Medieval Armenian historians have reported about water supply to the Hellenistic cities of

Armenia. The cities of Armenia were built along the banks of the rivers. For example, Movses Khorenatsi, describing the foundation of the city of Yervandashat, emphasizes the removal of the Araks River from the hills of the city of Argishtikhinili and especially mentions the construction of water supply to the city of Yervandashat [4].

The centralized water supply of cities reaches high perfection in the Greek-Roman world. The construction of water pipes became widespread in the countries of the Middle East during the Hellenistic, especially in the Roman period. Excavations in Armenia of the ancient period have revealed pottery water pipes in various districts of the city of Artashat and the Garni fortress, as well as drainage canals, which confirms the existence of the public utility of the ancient cities described by medieval historians.

Artashat water main

The capital of Armenia, Artashat, was founded in the second century BC, and like an Urartian city, was built on the banks of the Araks and Metsamor rivers. In contrast to the Urartian cities, excavations in ancient Artashat have revealed a more perfect water supply system.

In 1987 in the vicinity of Artashat, during construction work, a city water supply was opened, which, based on its size, was the water main. The water supply consisted of oval-shaped pottery pipes with dimensions of 55 x 40 *cm* (major and minor axes) whose lengths were 16 -18 *cm* (Fig. 3).

These pipes were tightly fitted to each other, and the joints were covered from above with the similar pipes. Water was supplied, probably, from the southern mountains. This is one of the water mains leading to the city of Artashat, which, based on archaeological finds found around this pipeline, dates back to the 1st century AD.

Fig. 3. Water main of Artashat

On the territory of the citadel of the city of Artashat and nearby hills, as well as in the lower city, a large number of pottery pipes of various sizes, including elbow pipes used to change the direction of the water supply were found (Fig. 4).

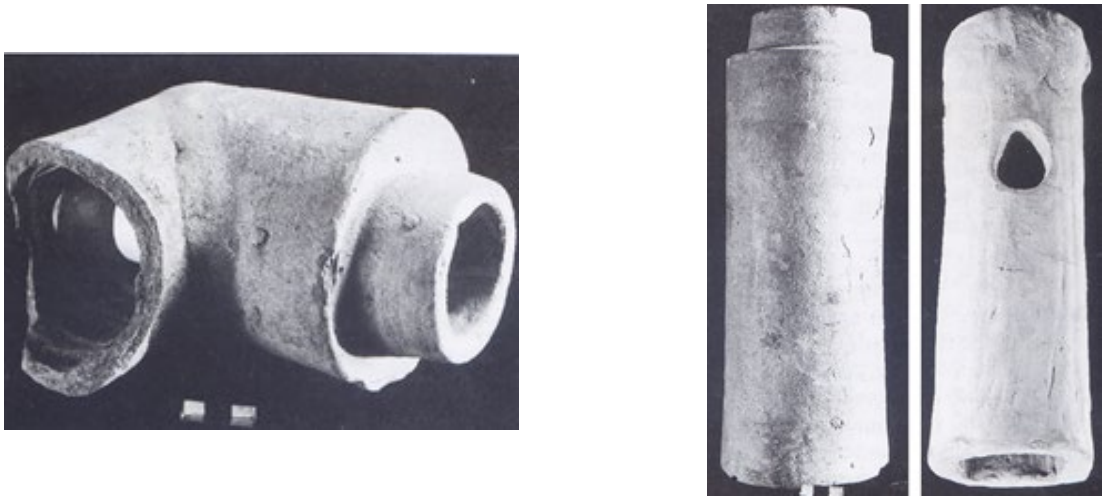

Fig. 4. Pottery pipes of Artashat

A large number of pottery pipes of various sizes found in Artashat indicate the presence in the city of both main and side water supply lines diverging through the city.

Artashat pottery kiln

In Armenia, as in the entire Hellenistic world, there was a ceramic production, with special kilns for firing pottery pipes used for water pipes. On one of the hills of the upper city of Artashat, near the fortress wall, a small pottery workshop with a kiln and a bath for soaking terracotta was excavated (Fig. 5). A total of 20 burnt pottery pipes were found in the furnace heap (Fig. 6), which indicates their local production. The kiln was built of fired bricks with high thermal insulation properties, identical to the known small kilns of the ancient world [4]. In order to give strength, the furnace was surrounded on three sides by walls and the space between them was clogged with clay.

Despite the poor preservation of the kiln, we tried to restore it (Fig. 5). The kiln was installed on a deepened rock base and had a round shape in the plan with a diameter of 1.53 *m*; walls of the kiln had clay coating. The furnace room was below the level of the modern surface of the earth; a burning chamber with a vault towered above it. The annular wall of the kiln is divided by an internal vaulted ceiling into two parts: the lower one is the furnace room, and the upper one is the burning chamber. To create the required temperature in the burning chamber, there were holes in the ceiling of the furnace. Unfortunately, the upper vault was destroyed, but it can be restored by analogy with other antique kilns (Fig. 5). Clearing the Artashat kiln showed that there was no transverse support wall in the furnace compartment, as it was assumed by Ter-Martirosov [5]. These support walls were made for large diameter kilns rather than in small antique kilns. The method of overlapping the firebox with arches is observed in a number of antique furnaces in Rome, Colchis, Iberia, Central Asia, and in the cities of the Northern Black Sea region [6].

Fig. 5. Excavation of a pottery kiln

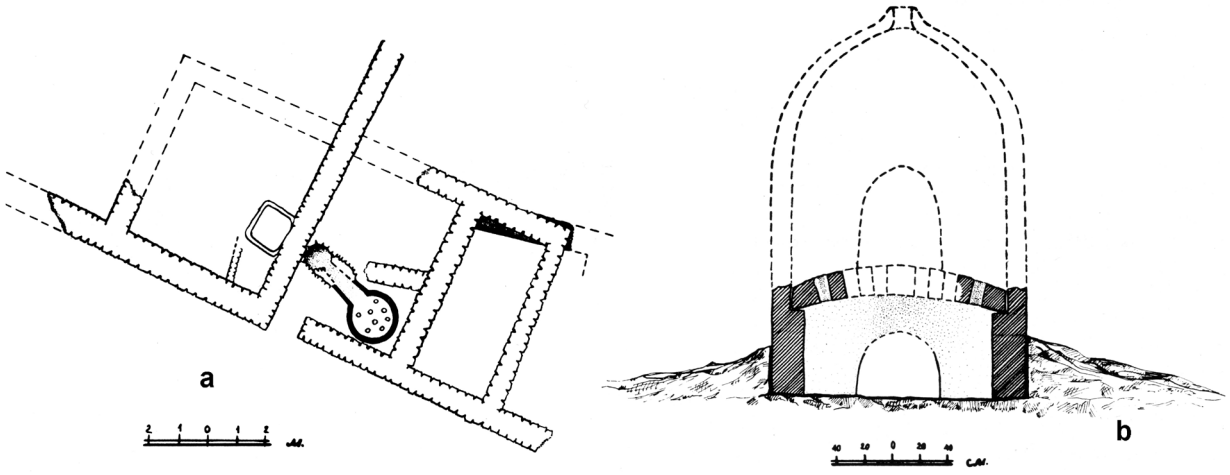

Fig. 6. a) Plan of the pottery workshop, b) Sectional drawing of the kiln

Excavations show that the water supply system, made up of pottery pipes, as in the entire Hellenistic world, was widespread in ancient Armenia of this period. Vitruvius, along with open channels and lead pipes, speaks of baked clay pipes and emphasizes their advantage [8].

Water pipelines of Artashat

As mentioned above, individual pottery pipes were found throughout the whole excavated territory of the city of Artashat, which indicates their widespread use. Water supply to Artashat was

based largely on the use of spring and river water. The water conduits were built on the principle of gravity. The study showed that when choosing a territory for construction, the terrain relief associated with the possibility of water supply and drainage was taken into account.

Of great interest is the area of the lower city, where a public bath with preserved water supply sections (segments) was excavated near the Araks River. During the excavations, small sections of pottery pipelines were found in many rooms of the bath. So, in the south-western room of the bathhouse, a segment of the pipeline with a length of 5.00 *m* was opened (Fig. 7), and at the western entrance to the bathhouse, a segment of 2.00 *m*. A pipeline with a length of 16.20 *m* was also discovered (Fig. 8). It bent around the bath building in a northern direction and was at a distance of 0.40 - 0.60 *m* from the southeastern and eastern sides of the building. Judging by the pipe fittings, the water flowed from north to south. The water supply sections consisted of separate pipes, which were joined together with a lime mortar. The sizes of these fired drainpipes are different: the length is from 0.30 to 0.42 *m*, and the wide diameter is 0.17 - 0.18 *m*, the narrow one is 0.14 - 0.15 *m.* During the excavation of a long pipeline, it was found that the pipes had small technical holes with baked clay plugs (Fig. 4) located at some distance from each other. We found and fixed water pipelines that were laid from the surface of the earth to various depths from 0.83 to 1.19 *m*. Underground pipe laying appears to have been used to protect against human damages as well as to prevent the pipes from over-expanding in hot weather. In addition to the pipelines described above, sections of pipelines leading from the bathhouse to another southern structure were discovered. The length of the western pipeline is 4.20 *m*, and the eastern one is 6.50 *m*, the last pipeline goes under the wall of the southern building (Fig. 9).

Fig. 7. Section of pipeline of bathroom

Fig. 8. The external pipeline of the bath facility

Fig. 9. Segments of pipelines in Artashat

Artashat water parting nodes

Excavations discovered water parting nodes in various rooms of the bath as well as under its outer southern wall. They are made from well-worked limestone blocks, many of which have been recycled. About ten such stones were found (Fig. 10).

All these blocks have different sizes (0.58 x 0.57 *m*, 0.50 x 0.52 *m*, 0.40 x 0.50 *m*, 0.25 x 0.30 *m*, 0.25 x 0.25 *m*, etc.). In the round holes of these stones, broken-off clay pipes are preserved. At the outer corner wall of the cool hall (tepidarium) of the bath, a complex node was excavated in situ, consisting of three water parting stones located at different depths and having round holes at

different heights (Fig. 11). These watershed stones are located close to each other. The largest stone with dimensions of 0.58 x 0.56 *m* has a height of 0.70 *m* (Fig. 12). This stone is of secondary use, earlier it was apparently used in a monumental structure, as evidenced by the preserved carved ornament in its lower part. The stone is located at a depth of 0.68 *m* from the earth's surface. There are four round holes with a diameter of 0.15 *m* on the upper surface of this stone, and one each on the western and eastern sides.

Fig. 10. Water parting stones of Artashat

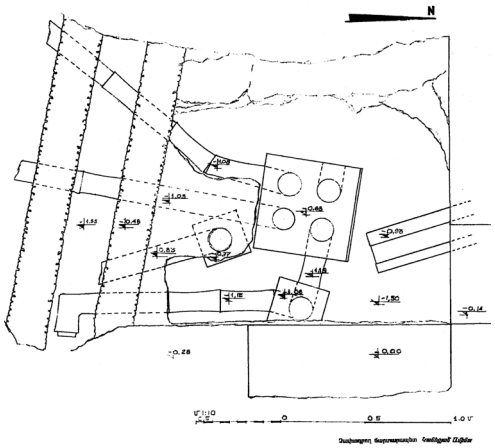

Fig. 11. Plan of the water parting node in Artashat

Fig. 12. The large water parting stone

There are four round holes with a diameter of 0.15 *m* on the upper surface of this stone, and one on the western and eastern sides. There are three holes on the southern side of the stone: two of the holes are in the lower part of the stone at a depth of 1.08 m, where the surviving pipelines are laid one to the south and the other to the south-west (Fig. 13). A small distribution stone measuring 0.27 x 0.27 *m* is adjoined to a large stone from the southeast corner at a depth of 0.77 *m* from the surface of the earth. This stone has one hole on the top and two on the southern and northeastern sides. One of the southern holes of the large stone is connected to the northeastern opening of the small stone by a drainpipe located at a depth of 0.82 *m*. This drainpipe, through the southeast opening of a small stone, continues in the form of a pipeline towards the southeast. On the east side, at a short distance from the large water distributor, a third distributor-stone with dimensions of 0.31 x 0.31 *m* is revealed. It is located at an angle to the large one; a part of the stone is under the wall of the bath at a depth of 1.06 *m*. On the upper surface, the stone has one hole; the western and southern walls also

Fig. 13. The system of water parting stones in Artashat

have one hole. The western hole of the stone is connected to the eastern hole of the large distributor-stone by a pottery pipe, which is laid to a depth of 1.19 *m*. From the hole of the southern wall of the stone, a pipeline 1.20 *m* in length runs in the direction of the south, which, with the help of a bent pipe, turns to the east (Fig. 11).

We have discovered and investigated a significant water parting node, as well as individual segments of pipelines, which make it possible to present a diagram of the directions of distribution of water flow in a given area, at different heights. As it turns out, water parting stones, in addition to changing the direction of water lines, also change the depth of laying pipelines from the surface of the earth. Unfortunately, excavations do not yet provide an opportunity to find out the location of the water source. One thing is clear that water was supplied from the Araks River, since this region is located on its bank. Similar water distributors are found in the constructions of the ancient period [8].

Drainage system of Artashat

In the area of the bath construction, sections of the bath drainage system were also found. The drainage system was a canal dug into the ground, which narrowed downward (the upper canal width was 0.22 - 0.30 *m*, the lower canal width was 0.19 - 0.22 *m*). The walls of the canals are lined with small stones, fastened with lime mortar (Fig. 14, 15, 16, 17, 18).

Fig. 14. Drainage section

Fig. 15. Eastern drainage conduit

Fig. 16. Southern sections of drainpipes and drainage system

Fig. 17. Drainage pipe system and drainage section

Fig. 18. Drainage canal

The inner surface of the canals was plastered with a waterproof lime mortal. From above, these channels were covered with large rough stones and then covered with earth. The main drainage system was excavated from the eastern side of the bath construction, which continues to the north, with a total preserved length of 53.00 *m*. The width of this drainage canal is 0.50 *m* at the top and 0.35 *m* at the bottom. This drainage system bifurcated, and one of its branches was laid to the south.

This branch of the drainage system was found under the southern buildings at a distance of 27.00 *m* from the bath facility.

Garni water supply

As a result of excavations in 1975 on the territory of the Garni fortress, an interesting water supply system was discovered (Fig. 19). It is a canal dug into the ground, which passes under the main entrance to the fortress and, forking, supplies water to the entire territory of the fortress (Fig. 20). Water came to the canal from springs located two kilometers from the village of Garni.

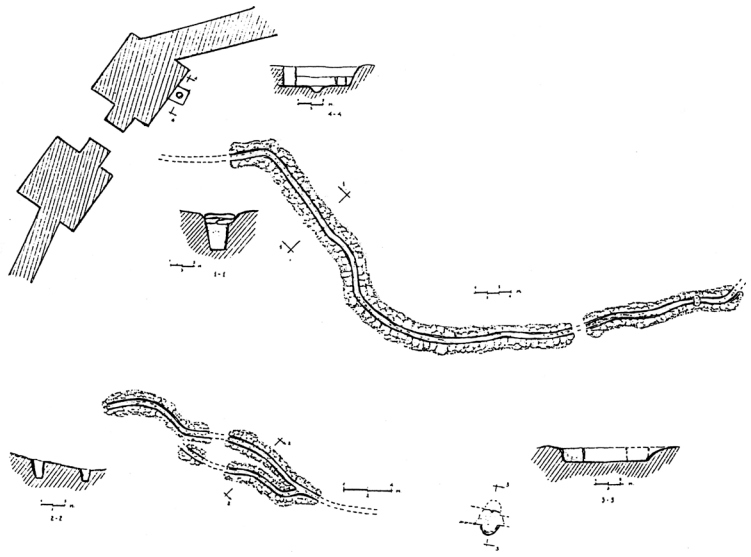

Fig. 19. Plan and sectional drawing of water pipelines in Garni fortress

Fig. 20. Water pipeline canal in Garni

The discovered part (excavations not completed) revealed two forks in the water supply system. The pipeline does not run in a straight line but makes many undulating bends. Due to the undulation of the channel, the distance between the branches is different. The branched part of the canal is located on the slope, as a result of which the main branch was located higher than the other. Under the fortress wall, not far from the entrance to the fortress, a rectangular water sump was opened. The dimensions of this sedimentation tank are 1.30 x 1.40 *m*, its depth from the day surface is 1.80 *m*. In the middle, there was a recess with a diameter of 0.50 *m* and a depth of 0.25 *m*. The dimensions of the main trunk line are larger than the dimensions of the branches. So, at the mainline, the channel width in the upper part is 35 *cm*, at the base – 28 *cm*, and the depth – 64 *cm*; at the first branch, the upper width is 16 – 17 *cm*, at the base – 13 *cm* with a depth of 33 *cm*; at the second branch, the upper width is 15 *cm*, at the base – 11 *cm* with a depth of 23 *cm*. The canals are trapezoidal in section, tapering downward. From above, the channels were covered with untreated basalt stones, the average dimensions of which were 0.37 x 0.43 *m* (height 0.10 *m*), connected to the sides of the channel with lime mortar. Both canals and sedimentation tanks were lined with untreated stones. The inner (bottom and sides) of them were carefully processed. They were covered with a special waterproof plaster, 1.5 - 2.0 *cm* thick, consisting of lime mortar, sand, and crushed bricks. The composition of such a solution (three parts of crushed brick and one part of lime), which was used in damp places and did not deteriorate, is mentioned even by Vitruvius [5] and Pliny [10].

In addition to the described water main, during the excavation of the Garni fortress, pottery pipes of different diameters from 11 to 19 *cm* were discovered, which represented a water supply system from the main to the structures. The Garni water pipes with a treated inner surface and covered with large rubble stones on top are very reminiscent of water drainage structures in the Hellenistic period.

Water reservoir

The water supply facilities also include a water reservoir discovered in ancient Artashat on the eighth hill, built into a rectangular room [11]. The preserved height of the walls is 1 *m*, the thickness of the walls of the reservoir is 0.30 *m*. In this structure, the water-tightness of the walls is solved in a very peculiar and interesting way (Fig. 21, 22).

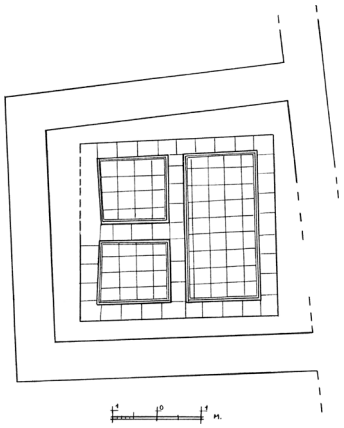

Fig. 21. Plan of the water reservoir in Artashat

Fig. 22. Water reservoir in Artashat

The walls themselves were made of adobe bricks, which were the basis for a waterproof lime layer. Studies have shown that this layer was applied in two steps. The first layer with a thickness of 1.20 *cm* was applied to the smooth surface of the adobe brick, after which reed rods were placed vertically at different intervals from 1.20 to 0.60 *cm*. After this layer was dried, a second layer 2.80 *cm* thick was applied, forming a monolith of concrete with a total of 4.00 *cm* thick.

Reed bars, apparently, ensured the resistance of the first layer, playing at the same time the constructive role of the reinforcement of all concrete, while not undergoing mechanical and hydrothermal deformation (due to the very low water resistance). The reed has decayed and vertical holes with traces of reed remained in the places of the twigs. Reed reinforcement simultaneously reduced the consumption of concrete, facilitated the physical and mechanical impact on the base, and added strength to the structure. The composition of the concrete ensured the water tightness of the pool. Here, as in all hydraulic coatings, there is a mixture of lime and crushed bricks.

The arrangement of the water reservoir floor is also interesting. Although it was dismantled, it is easy to restore its picture from the ceramic tiles and other remains preserved near the walls. The leveled surface was covered with lime mortar. On it were laid out well-fired square bricks (0.37 x 0.37 *m*) with a thickness of 0.05 *m*. The surface of these tiles was also covered with lime mortar of 1-2 *cm* thick.

The total area of the water reservoir is 12.95 square meters, the entire reservoir is divided by partitions into three parts, one of which is half the area, and the other two are almost equal. It is possible that from above these compartments were connected to each other by means of pottery water pipes, which were found to have collapsed into the pool. The presence of water pipes, double walls (walls of rooms and a pool) with hydraulic properties, which contributed to the preservation of cold and clean water, apparently indicates that this reservoir served as a cistern for drinking water. At the same time, in its shape and size, this basin resembles the fish-salting baths of the Northern Black Sea region [12]. The proximity of the Araks River suggests that the Artashat basin could well have served fish and salting purposes, but there is no evidence of this assumption. According to archaeological material, as well as stratigraphy, the basin dates back to the 1st century AD, as well as the fish-salting baths of the Northern Black Sea region.

Conclusion

From all that has been said, it is clear that the disclosed water supply and drainage systems of Artashat, like the Garni one dating back to the 1st century AD, are still the first such systems

excavated in ancient Armenia. From the data revealed by the excavations, it is obvious that the cities and settlements of ancient Armenia had a complex, ramified system of water supply and drainage systems, which indicates a high level of communal services.

In the cities of Armenia, there were local pottery workshops, which supplied these public buildings. Unfortunately, so far, it has not been possible to find a primary source of water supply. In the future, this complex water supply system continued to be built in medieval Armenia, as evidenced by the excavations of the town of Dvin (the 5th century AD) [13].

References

[1] B.Piotrovsky, History and Culture of Urartu, Art of Russia publishing house, St. Petersburg, 2011.

[2] K. Hovhannisyan, Erebuni Fortress, publishing house Hayastan, Yerevan, 1980.

[3] Movses Khorenatsi, History of Armenia, publishing house Hayastan, Yerevan, 1990.

[4] V.F.Gaidukevich, Antique ceramic kilns, OGIZ, Moscow - Leningrad, 1934.

[5] F.Ter-Martirosov, Antique kilns from the excavations of Artashat, Bulletin of Social Sciences of the Academy of Sciences of the Arm. SSR. 7 (1975) 70-84.

[6] G.A.Tiratsyan, Transcaucasia, in Rybakov B.A. (ed), The most ancient states of the Caucasus and Central Asia, Nauka, Moscow, 1985, p.482.

[7] Vitruvius, The ten books on architecture: book 8, The All-Union Academy of Architecture, Moscow, 1936.

[8] C.S.Fisher, The tower area, Antioch on-the-ozontes. 1(1938)1-31.

[9] A.G. Kanetsian, Cities and settlements in Armenia of Classical Age, Publishing House Le lettere, Turin, 1998.

[10] The architecture of the antique world, in Zubova V.P., Petrovsky F.A. (eds.), Publishing house of the Academy of Architecture of the USSR, Moscow, 1940. p. 257.

[11] V.F. Gaidukevich, Excavations of Tiritaka and Myrmikey in 1935-1938, MIA, Moscaw-Leningrad, 1958.

[12] R.V. Epremyan, Water supply of ancient and medieval Armenia YerASI, Yerevan, 1992.