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Research Article

New Excavations of a Section of the Late Roman (Valens) Aqueduct in İstanbul

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ABSTRACT

İstanbul, throughout history, has been home to several civilisations and has been named differently by each civilisation. As the direct and indirect source of life, the need for water was one of the most important requirements of İstanbul's populace. In this context, the city is known to have received its first long-distance aqueduct during the Roman Empire under the reign of Emperor Hadrian (AD 117-138). Later, a second aqueduct was constructed during the reign of Emperor Valens (AD 364-378).

A vaulted channel belonging to a Roman Age aqueduct discovered under the foundations of old structures removed during an urban transformation project constitutes the subject of this work. The aqueduct composed of a vaulted channel is located within Gaziosmanpaşa Municipality's Bağlarbaşı District near Adsız Nefer Street and holds important information regarding the aqueducts of İstanbul which began to be utilized to bring water from far destinations.

With knowledge from previous research, this work aims to investigate and identify which aqueduct line the channel belongs to and to contribute to the knowledge regarding the city's water supply.

Keywords: İstanbul, Aqueduct, Water Supply, Vaulted Channel, Roman Age Archaeology

Introduction

İstanbul, throughout history, has been home to several civilisations and has been named differently by each civilisation. The city was named Byzantion/Byzantium during the Greek and Roman Ages, later during the Late Roman and Byzantine Empire the city was known as Konstantinoupolis and eventually during the Ottoman Empire and the Turkish Republic, it was renamed İstanbul.

As the direct and indirect source of life, the need for water was one of the most important requirements of the cities' populace. In this context, the city is known to have received its first long-distance aqueduct during the Roman Empire under the reign of the Emperor Hadrian (AD 117-138) (Çeçen, 1991, 23; Mango, 1995, 10; Çeçen, 1996, 20; Crow et al., 2008, 10-14; Crow, 2012b, 118; Ward et al., 2017, 178,179-180; Ruggeri, 2018, 34; Ward, 2018, 349; Öziş et al., 2023, 81). Later a second aqueduct was constructed during the reign of the Emperor Valens (AD 364-378) (Çeçen, 1991, 23; Mango, 1995, 12; Çeçen, 1996, 20; Crow et al., 2008, 9-14; Crow, 2012b, 118; Snyder, 2013, 7-8; Ward et al., 2017, 179-180,185; Ruggeri, 2018, 34-36; Ward, 2018, 349,357; Öziş et al., 2023, 81). Throughout the following ages, the city's aqueducts were renovated and extended. Although these aqueducts were not the city's only aqueducts, they are known as being the oldest ones in the city. The city is known to have had many aqueducts during the Ottoman Empire (Çeçen, 1991, 55-168; Çeçen, 1996, 73-99; Öziş et al., 2020, 13-16).

The Channel's Composition

The section of the aqueduct (Fig. 1) which is the topic of this work consists of a vaulted channel unearthed from below the foundations of old structures which had been removed during an urban transformation project[1]. The channel is located within the Bağlarbaşı district of Gaziosmanpaşa Municipality close to Adsız Nefer Sokak (Fig. 2).

The coordinates[2] of the channels most northwest (sourceward) are 41°4'2.90"N, 28°54'57.36"E. The distances of the channel to some of the major land marks are as: 4.2 km northwest of the Eğrikapı / Theodosian Wall (crossing point), 6.3 km northwest of the Bozdoğan Kemeri and 2 km north of Rami Kışlası (Rami Barracks). Measured elevation of the channel floor is 60.500 m asl at the northwest (sourceward) and 60.488 m asl at the southeast (cityward), above the vault of the channel at the northwest (sourceward) is measured as 62.65 m asl. The distance between these measurements is 122.23 m resulting in the gradient being almost 0.001% (0.00098%)[3].

1 The channel of interest will be preserved in-situ and this project will be a topic of another paper.
2 The coordinates were taken from Google Earth.
3 It should be noted that the GPS CORS was held by the author during the documentation. During the coordinate reading for the northwest reading the channel floor was observed and during the southeast reading the floor was not observed due to the water being unclear. Therefore the gradient calculation might have errors.

Figure 1: Aerial photograph of the aqueduct channel.

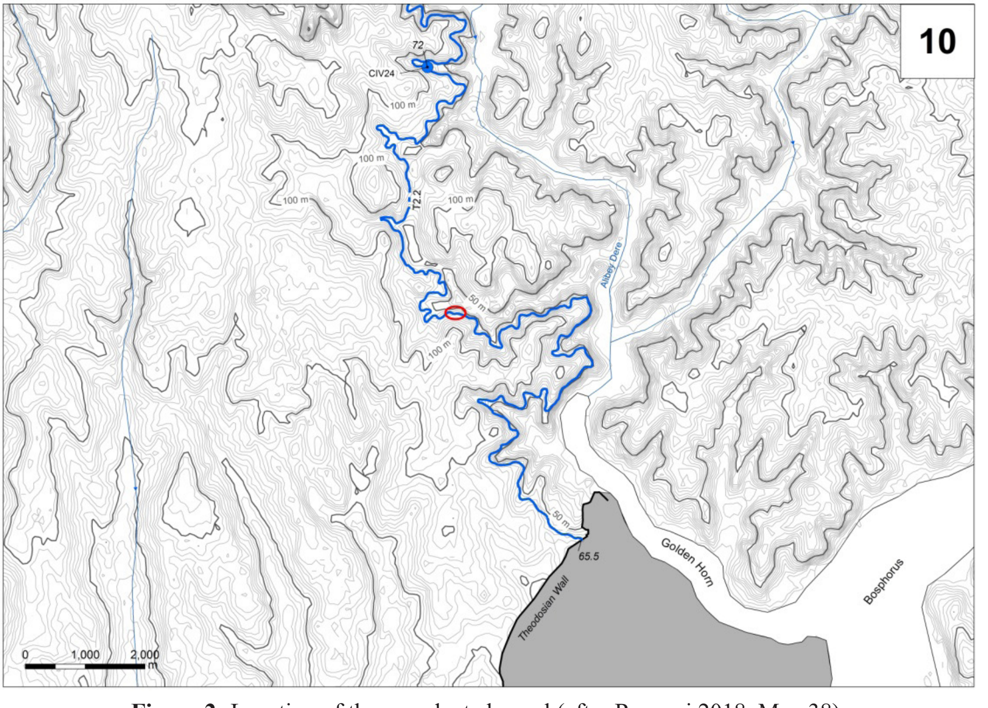

Figure 2: Location of the aqueduct channel (after Ruggeri 2018, Map 38).

This channel, to keep the required gradient was constructed with bends following the contours of the topography. A significant detail regarding the construction is the positioning of the channel inside the foundation bed prepared by carving the bedrock (Fig. 1,3). The stones used for the construction of the walls of the channel are also from the same rock, revealing that excess material from the bedrock carving has been re-utilized. This detail reveals the site of construction was also used as a quarry for the intended construction, which reduced the need to have construction materials transported for the construction. The topography of the land as well as the bedrock formation would have been the direction criteria for the course of the aqueduct.

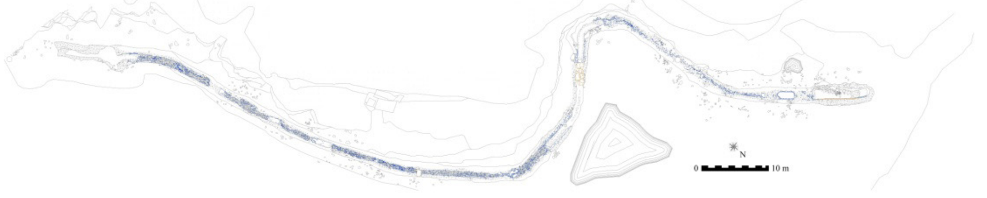

Figure 3: Plan of the aqueduct channel (Blue= original phase, Orange= Ottoman phase).

Figure 4: Aerial view of the vaulted aqueduct channel.

Dimensions[4] of the channel are measured as 180-200 cm in height, 92 cm in width, and with a wall thickness of 30-33 cm (Fig. 4-6). The springing point (impost point) of the channel is 150 cm high and the vault over it was constructed with rubble stones utilizing mortar (Fig. 4-10). The side walls of the channel are understood to have been constructed by using slates of the local stone (sandstone and limestone) and utilizing pink-coloured hydraulic mortar (*opus signinum*), without the usage of plaster or lining on the inner walls of the channel. The omission of plaster or lining being used reveals the local stone (bedrock) to be impervious. Although the side walls were constructed without the execution of hydraulic plaster or lining,

4 Dimensions of the channel are greater than the 4th century channels of 65 cm wide, 100 cm height (springing point), though inferior to the 5th century channels of 160 cm wide, 170 cm height (springing point) (Crow et al., 2008, 27; Ruggeri, 2018, 41, Fig. 3.2-3.3; Crapper, 2020, 428-429).

It should also be noted that within the 4th century channels there are examples of the exact same sizes (Ruggeri, 2018, Fig. 3.3).

hydraulic plaster was used on the channel floor[5]. In the corners where the channel floor and side walls meet, traces of fillets are not found. As the floor lining is intact and has no traces of fillets, reveals the channel floor and side walls to have been joined without the use of fillets[6].

Figure 5: Vault from the original phase of the aqueduct channel.

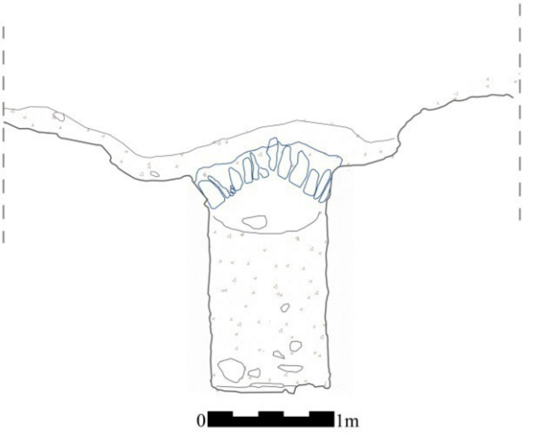

Figure 6: Cross-section drawing of the vault from the original phase of the aqueduct channel.

5 The channels differ from the previously documented channels regarding the absence of the hydraulic plaster/lining on the side walls (Ruggeri, 2018, 41, Fig. 3.2).

6 The detail regarding the fillets will be discussed further in the conclusion.

The vault of the channel and the superstructure of the channel are observed to be depredated in some parts and some of these depredations are observed to have been renovated during the Byzantine and Ottoman Ages however some of the damage is understood to have been caused after the channel was no longer servisable and ceased to be used (Fig. 4,9-10). In some parts the depredation is not only on the superstructure but also on the side walls, with some of the walls having been totally destroyed however through the rest of the channel and the bedrock the direction of the channel is understood (Fig. 1,4,9).

Figure 7: Damaged vault from the original phase of the aqueduct channel.

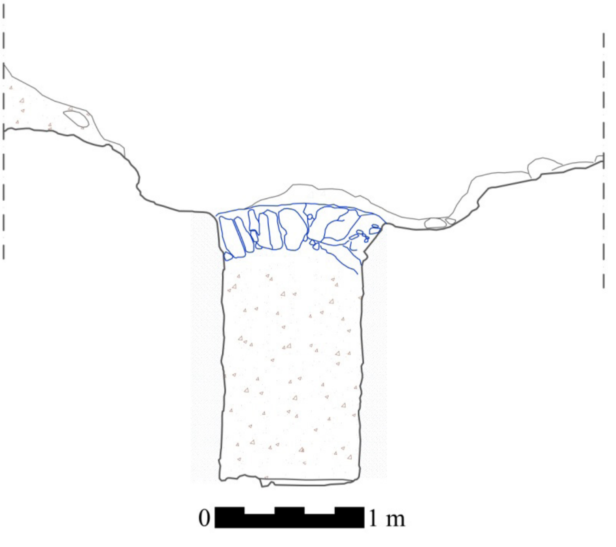

Figure 8: Cross-section drawing of the damaged vault from the original phase of the aqueduct channel.

The renovations that were carried out during the Byzantine and Ottoman Ages are observed to have utilized white-coloured lime-based mortar and the collapsed sections of the vault were renovated by using lids or large blocks fashioned from mantra limestone (Fig. 9,11). However, due to these renovations and the lack of evidence on the original vault, no traces are witnessed regarding the airing shafts.

Figure 9: Vault from the Ottoman renovation phase of the aqueduct channel.

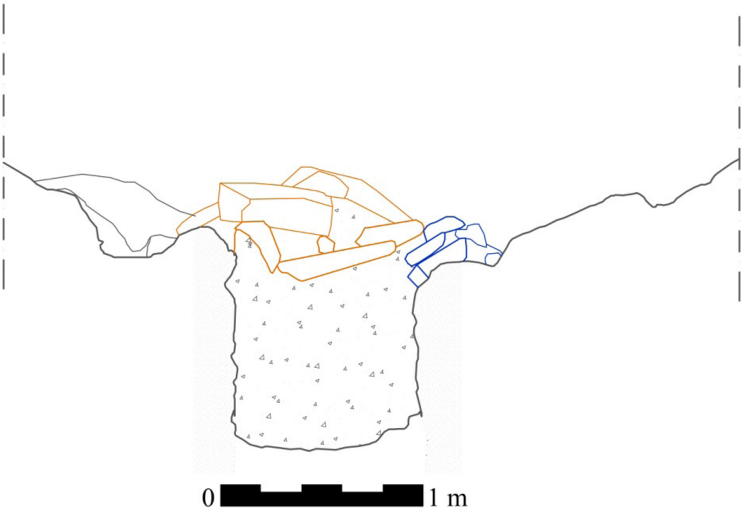

Figure 10: Cross-section drawing of the vault from the Ottoman renovation phase of the aqueduct channel.

Figure 11: Vault from the Ottoman renovation phase with mantra limestone lids.

The excavations conducted on the channel were carried out after the demolition of the old unsafe buildings on the site, therefore some parts of the vaults were damaged before the discovery and identification of the channel. After the channel remains were understood to be archaeological, rescue excavations were conducted. During the construction of the mentioned buildings over the channel which took place approximately 60 years ago, some damage was caused before the demolition of these buildings. This is understood from some of the foundations being directly over the channel. The excavations were conducted between the modern rubble and the archaeological layers.

During archaeological research within the channel sadly a stratigraphy was not observed within the fill, close to the floor a limited amount of pottery fragments dating to the Late Byzantine and Ottoman Ages were found. The architectural features and the finds from within the channel indicate that the channel was originally built during the Late Roman Ages. The architecture of the channel is similar to previously published channels between Tayakadın and Edirne Kapı (Theodosian Wall) in regards to the vaults (Çeçen, 1996, 115-116,121,124) and side walls (Çeçen, 1996, 115-116,121-123).

Related Aqueduct

According to the location, the aqueduct channel should be part of either the two Ottoman Aqueducts[7] in the area: the Halkalı Aqueduct or the Kırkçeşme Aqueduct which are mentioned to have been built during the reign of the Late Roman/Byzantine Emperors Valens (AD 364-378) and Theodosius I. (AD 378-395) respectively (Çeçen, 1991, 171-172; Çeçen, 1996, 76,80,215-216; Crow, 2007, 270; Crow et al., 2008, 9-15,87, fn. 109; Crow, 2012a, 40). Though it should be noted that Byzantine sources mention an Aqueduct of Hadrian which

7 The Ottoman aqueducts are known to have changed the sources and the course of previous aqueducts of the city with renovations.

is referred to as "the aqueduct of the city" which is distinct from the Aqueduct of Valens (Crow et al., 2008, 10-14, 114-117; Crow, 2012a, 38, 42) (Fig. 12). It is also mentioned that the Aqueduct of Theodosius I. is most likely the new name of the renovated Aqueduct of Hadrian or Valens, which most likely is the former (Çeçen, 1996, 214; Crow et al., 2008, 16). The Hadrianic Aqueduct is stated to have entered the city close to the Kırkçeşme Aqeuduct's distribution chamber in the vicinity of Eğrikapı at 35 m altitude (Çeçen, 1996, 82; Crow, 2007, 273-276; Crow et al., 2008, 115; Crow, 2012b, 120; Snyder, 2013, 7-8, Map. 2.1; Ruggeri, 2018, 60; Ward, 2018, 191). While the Valens Aqueduct enters the city by crossing the Theodosian Wall at 55-65 m altitude close by to Edirne Kapı (Çeçen, 1996, 120-121; Crow, 2007, 273-276; Crow et al., 2008, 27,120-121; Crow, 2012b, 120; Snyder, 2013, 8-9, Map. 2.1; Ruggeri, 2018, 60; Ward, 2018, 221). The Kırkçeşme Aqueduct is located 60 m in distance to the northeast and located parallel to the channel of interest, resulting in the channel belonging to the Ottoman Halkalı Aqueduct and Roman Valens Aqueduct therefore dating to the reign of Emperor Valens (Fig. 2) (Çeçen, 1991, Plan 6; Çeçen, 1996, 80; Crow et al., 2008, Fig. 2.1-2.2; Crow, 2012a, Fig. 2; Ruggeri, 2018, 60, Map 5).

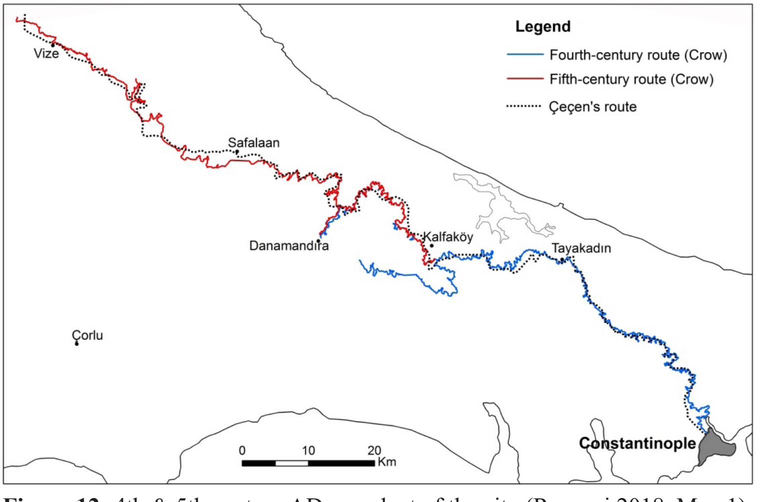

Figure 12: 4th & 5th century AD aqueduct of the city (Ruggeri 2018, Map 1).

Halkalı sources began to be used after the 15th century AD by the Ottomans (Çeçen, 1991, 25-28; Çeçen, 1996, 76-79; Bono et al., 2001, 1333; Crow, 2007, 274-275; Crow et al., 2008, 22-23,28), therefore for the Roman Age aqueducts the aqueduct will be referred to as the Aqueduct of Valens.

Previous works carried out on the ancient aqueducts of İstanbul present some information relating to the area of the channel of the topic. According to Çeçen's work, the area of study is located between the aqueduct bridges known as Sinekli Kemer and Kuyu Keçelik Kemeri (Çeçen, 1996, 75,7).

The sources and springs for this aqueduct (Valens) are mentioned to have been surveyed during the reign of Constantius II. in 357 AD (Crow 2012a, 39; Crow 2012b, 117-118). After the completion of the construction the Aqueduct of Valens is known to have brough water to the city in 373 AD (Mango, 1995, 12; Çeçen, 1996, 20,216; Crow, 2007, 270; Crow et al., 2008, 225; Crow, 2012a, 39; Crow, 2012b, 118; Crapper, 2020, 427) and that it utilized bridges and tunnels (Crow et al., 2008, 224; Crow, 2012a, 39; Crapper, 2020, 427). The water source chosen for the Aqueduct of Valens is known as the Danamandıra and Pınarca district's waters (Crow, 2007, 272-273; Crow et al., 2008, 14-15,118; Crow, 2012a, 40; Crow, 2012b, 122,124; Snyder, 2013, 9-10, Fig. 2.1; Ruggeri, 2018, 38-40,50-53,54,56, Map 1,3,4; Ward, 2018, 119-121, Map. 5.3; Crapper, 2020, 427-428, Fig. 1; Öziş et al., 2020, 11; Öziş et al., 2023, 81) and later the additional Vize distrcit's waters (Mango, 1995, 12-14; Bono et al., 2001, 1325,1327; Crow, 2007, 270,273; Crow et al., 2008, 25; Crow, 2012a, 40; Crow, 2012b, 122-123; Snyder, 2013, 9-10, Fig. 2.1; Ruggeri, 2018, 40,50-54,56, Map 1,3,4; Ward, 2018, 119-121, Map. 5.3; Crapper, 2020, 427-428, Fig. 1; Öziş et al., 2020, 11; Öziş et al., 2023, 81).

Additions to the aqueduct are understood to have been made during the reign of Theodosius I (AD 379-395) and later during the renovations of Justinus II (AD 565-578). The Valens Aqueduct as well as the Hadrian Aqueduct are known to have been renovated during 575-576 AD (Crow, 2007, 270; Crow et al., 2008, 16-17; Crow, 2012a, 48; Crow, 2012b, 131). During the reign of Constantine V (741-775 AD), both of the aqueducts (Valens and Hadrian) were once again renovated (Mango, 1995, 17; Crow et al., 2008, 19-20; Crow, 2012a, 49; Crow, 2012b, 133,135; Ruggeri, 2018, 34-38, Fig. 3.1).

Halkalı sources began to be used after the 15th century AD (Çeçen, 1991, 25-28; Bono et al., 2001, 1333; Crow, 2007, 274-275; Crow et al., 2008, 22-23,28. Çeçen, 1996, 76-79). In other words, additional closer water sources were tapped by branches were added to the existing aqueduct during the Ottoman renovations. During these renovation and construction activities, the Bozdoğan Kemeri is known to have been renovated and utilized for the (Ottoman) Halkalı Aqueduct during the reign of the Ottoman Sultan Mehmet II the Conqueror (AD 1451-1481) (Çeçen, 1991, 134-138; Çeçen, 1996, 51-53; Crow et al., 2008, 22-23) and later renovated once again in 1790 by Ali Paşa (Çeçen, 1991, 25-28).

Valens Aqueduct's course followed the western bank of the Alibey River. Though it is mentioned that due to the Alibey Dam, the aqueduct cannot be observed at the location of the dam (Crow, 2007, 273; Crow et al., 2008, 27).

Different approaches for the aqueduct course are taken in various researches (Ruggeri, 2018, 48, Map 2). In various studies, the length of the Aqueduct of Valens is mentioned as being 242 km (Çeçen, 1996, 132,216), 246 km (Ward, 2018, 280) 426 km (Ward et al., 2017, 176; Ruggeri, 2018, 97-98,120, Table 5.3), 454 km (Crow, 2012a, 41; Snyder, 2013, 199-200, Tab. 7.3) and 592 km (Crow et al., 2008, 26).

According to one of these researches, the average gradient from Kalfaköy to İstanbul is calculated as 4% (Ruggeri, 2018, 99-100, Table 5.4), and the flow rate is calculated as 0.7 m3/s on annual average (Ruggeri, 2018, 202-203, Table 7.12). And the daily amount of water per capita is calculated as 160-320 liters (Ruggeri, 2018, 224-227, Table 7.12; Ward, 2018, 271-27).

In regards to the construction details of the aqueduct within the modern city of İstanbul, the channel above the Bozdoğan Kemeri is published as being 0.92 m in width and 1.88 m in height (Crow et al., 2008, 119; Ward, 2018, 280). A published photograph of a channel upstream of the Bozdoğan Kemeri which might belong to the Valens Aqueduct reflects the brick channel has a vaulted cover and no hydraulic lining on its walls (Ward et al., 2017, 186, Fig. 5; Ward, 2018, 208-211, Fig. 6.8). Dimensions of this channel are given as 2 m wide and 2.5 m tall. The channel either belongs to another aqueduct line or the outer dimensions are presented instead of the inner dimension. Therefore using the known dimensions of the channel above the Bozdoğan Kemeri will be more accurate. The Bozdoğan Kemeri was produced with coursed grey limestone ashlar and mortared grey limestone rubble with the usage of pinkish mortar (Ward-Perkins, 1958, 65; Snyder, 2013, 29-30). Byzantine mortars are known to have ranged from grey to pink, the pink or pinkish mortar being known to have been produced with crushed brick and brick dust since the Roman Ages (Ousterhout, 2008, 134; Snyder, 2013, 215-216, Table 7.8).

The location of the channel of topic runs through a paleozoic complex which consists of shale, sandstone, marl, and limestone (Snyder, 2013, 134, Map. 5.2). Greenstone is mentioned as a local stone that is disintegrated granite; hard but coarse-grained and is known to scale easily (Ward-Perkins, 1958, 53-54). Other stones known to be used in the Aqueduct of Valens are; tertiary limestone or cream to grey sandstone, both are known to be quarried locally in the vicinity of Bakırköy (ancient Hebdomon) and mantra limestone known to have been quarried from Bakırköy and Sefaköy (Safraköy). The latter is known to have been used throughout the Byzantine Period (Ward-Perkins, 1958, 53-55; Ousterhout, 2008, 136; Snyder, 2013, 30).

Conclusion

The water channel which is the topic of this work is important for providing information regarding the aqueducts of the Late Roman Age İstanbul (Byzantium), as well as the renovation and extensions that were carried out on these earlier aqueducts during the later periods and ages for the city’s need of water. The obtained information ranges from the path of the aqueduct to the renovation and usage phases of this particular aqueduct.

The dimensions of the channel by being the same as the channel of the Bozdoğan Kemeri together with the building techniques used reflect the channel as being part of the Valens Aqueduct with similar masonry (Çeçen, 1996, 115-116,121-124).

Previously some parts of the aqueduct were unknown and therefore the maps produced regarding the aqueduct were incomplete. The new evidence presented in this work supplements our previous knowledge, though the course of the aqueduct is still not precisely known as a whole.

Elevation of the channel is the floor is measured as 60.500 m asl at the northwest (sourceward) and 60.488 m asl at the southeast (cityward) giving a gradient of almost 0.001% (0.00098%) at 122.23 m distance at the researched area[8]. Above the vault of the channel at the northwest (sourceward) part is measured as 62.65 m asl. The channel should have been carrying the water to the Bozdoğan Kemeri as both are part of the Valens Aqueduct. Though when some measurements are compared it seems impossible due to the Bozdoğan Kemeri being given at the altitude of 60-61 m (Çeçen, 1991, 134), though when more recent studies are taken into consideration the height of the channel is given as 56-57 m asl and the water entering the city below the Theodosian Walls at 59.5 m asl (Crow et al., 2008, 118,120-121) and with these measurements, the channel would certainly have been able to convey the water to the Bozdoğan Kemeri.

Approaching the numeric data it seems that the old research may have been using another base value for the 0 point. If the data had not corresponded to each other the channel would require to have had a sudden, approximately 22 m loss of elevation to join the Hadrianic Aqueduct (Çeçen, 1996, 120-121; Crow et al., 2008, 85 fn. 107). Therefore numeric values need to be reassessed.

Additional information on the aqueduct's path is to be found in the techniques and architecture that were used to convey the water during the Late Roman Age. According to the newly gained information the channel consisted of orderly and neat walls which were covered over by a barrel vault. The channel was constructed into a foundation bed which was carved into the bedrock and during this process, the excess material from the shaping of the bedrock was utilized as construction material for the channel's architecture. Judging the foundation bed carved into the bedrock, surveying instruments mentioned by Vitruvius (VIII.5.1-3): such as the *dioptra* and *chorobates* should have been used for the surveying required for the gradient calculations which are referred to as *perlibratio* not only for during the construction but also before the construction during the bedrock carving. The lack of hydraulic lining or plaster on the walls of the channel, reveals the local stone which was

8 The gradient calculation might not reflect absolute presicion due to the southeast part being under unclear water.

also used for the construction to be impervious. Having hydraulic lining on the floor of the channel combined with the absence of fillets on the joining corners between the floor and the walls reflect the water conveyed to have had no hard impurities (Keleş & Yılmaz, 2020, 142-144,146; Yılmaz, 2021, 68,71-73). The conveyed water being free of hard impurities at this section of the aqueduct makes one (or more) of the following remarks to be the characteristic of the aqueduct itself:

The spring structure of the aqueducts may have an incorporated settling tank,

The aqueduct has a settling tank or settling tanks between the studied section and the spring,

The spring structure for collecting water utilizes a sluiceway taking water from above,

The spring does not contain hard impurities such as sand or stones.

The aforementioned remarks and possibilities give us preliminary notions regarding the Late Roman Aqueduct of İstanbul. With further evidence and studies, the topic will need to be re-evaluated.

The wider channels mentioned in previous studies might be settling pits among the aqueduct channel (Ruggeri, 2018, 49, Fig. 3.6, 3.8). One very important detail is that judging the earlier documentation of the channels the measurements were taken with earth within, therefore settling tanks would not be possible to be identified[9]. As Hodge states settling pits along the aqueduct are constructed by having the channel made wider and deeper in required areas (Hodge, 2002, 103,123-125). Though not many settling pits are documented (Hodge, 2002, 124), most likely due to damages or insufficient exploration[10].

Archaeological evidence reveals that the channel continued to serve the city with renovations and additions during the Byzantine and Ottoman Ages. The stones used for these renovations as well as the mortars do not resemble the choices of the original construction phase of the channel. The choice of mortars hints at these renovations being conducted during the Ottoman Ages rather than the Byzantine Ages.

With further evidence and studies on the channel of the Roman Aqueduct of the city, hydraulic calculations as well as further insight regarding the city's urbanization will be brought to light and will contribute greatly to the understanding of the Roman and Late Roman Ages in İstanbul.

9 Widening of water channels in order to accomodate a settling tank is known from Aqueduct Bridge of Parion (Keleş & Yılmaz, 2020, 142-144; Yılmaz, 2021, 71-72).

10 It should be noted that unearthing and completely documenting an aqueduct is almost impossible, even if the complete length of the aqueduct was preserved.

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References

Bono, P., Crow, J. & Bayliss, R. (2001). The Water Supply of Constantinople: Archaeology and Hydrogeology of an Early Medieval City. *Environmental Geology*, 40, 1325-1333.

Crapper, M. (2020). The Valens Aqueduct of Constantinople: Hydrology and Hydraulics. *Water Hist*, 12, 427-448.

Crow, J. (2007). The Infrastructures of a Great City: Earth, Walls and Water in Late Antique Constantinople. In L. Lavan, E. Zanini & A. Sarantis (Eds), *Technology in Transition A.D. 300-650* (pp. 251-285). Brill: Leiden.

Crow, J. (2012a). Ruling the Waters: Managing the Water Supply of Constantinople, AD 330-1204. *Water Hist*, 4, 35-55.

Crow, J. (2012b). Water and Late Antique Constantinople: "It would be abominable for the inhabitants of this Beautiful City to be compelled to purchase water.". In L. Grig & G. Kelly (Eds.), *Two Romes: Rome and Constantinople in Late Antiquity* (pp. 116-135). New York: Oxford University Press.

Crow, J., Bardill, J. & Bayliss, R. (2008). *The Water Supply of Byzantine Constantinople*. London: Society for the Promotion of Roman Studies.

Çeçen, K. (1991). *İstanbul'un Vakıf Sularından: Halkalı Suları*. İstanbul: İstanbul Büyük Şehir Belediyesi İstanbul Su ve Kanalizasyon İdaresi Genel Müdürlüğü.

Çeçen, K. (1996). *Roma Suyollarının En Uzunu*. İstanbul: Türkiye Sınai Kalkınma Bankası.

Hodge, A.T. (2002). *Roman Aqueducts & Water Supply*. London: Bristol Classical Press.

Keleş, V. & Yılmaz, M.D. (2020). Aqueduct Bridge of Parion and its Settling Tank. In G. Wiplinger (Ed.), *De Aquaeductu Urbis Romae. Sextus Iulius Frontinus and the Water of Rome: Proceedings of the International Frontinus Congress on the History of Water Management and Hydraulic Engineering in the Mediterranean Region. Rome, November 10-18, 2018* (pp. 137-148). Leuven: Babesch/Peeters.

Mango, C. (1995). The water supply of Constantinople. In C. Mango & G. Dagron (Eds.), *Constantinople and its Hinterland: Papers from the Twenty-seventh Spring Symposium of Byzantine Studies, Oxford, April 1993* (pp. 9-18). London: Routledge.

Ousterhout, R. (2008). *Master Builders of Byzantium*. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology.

Öziş, Ü., Alkan, A., & Özdemir, Y. (2020). From Rome to Istanbul: Parallels in Water Conveyance Systems to Rome and Istanbul through Two Millennia. *Schriftenreihe Der Frontinus-Gesellschaft*, 32, 7-21.

Öziş, Ü., Baykan, O., Atalay, A., Arısoy, Y., Alkan, A. & Özdemir, Y. (2023). *From Past to Present Water Works in the World*. İzmir: Dokuz Eylül Üniversitesi Mühendislik Fakültesi Yayınları.

Ruggeri, F. (2018). *Engineering the Byzantine Water Supply of Constantinople: Mapping, Hydrology and Hydraulics of the Long Aqueducts Outside the City*. (Doctoral dissertation, University of Edinburgh). Retrieved from: https://era.ed.ac.uk/handle/1842/31521

Snyder, J.R. (2013). *Construction requirements of the Water Supply of Constantinople and Anastasian Wall*. (Doctoral dissertation, University of Edinburgh). Retrieved from: https://era.ed.ac.uk/handle/1842/8257

Ward, K. (2018). *An Engineering Exploration of the Water Supply System of Constantinople*. (Doctoral dissertation, University of Edinburgh). Retrieved from: https://era.ed.ac.uk/handle/1842/33033

Ward, K., Crow, J. & Crapper, M. (2017). Water-supply Infrastructure of Byzantine Constantinople. *Journal of Roman Archaeology*, 30, 175-195.

Ward-Perkins, J.B. (1958). Notes on the Structure and Building Methods of Early Byzantine Architecture. In D. T. Rice (Ed.), *The Great Palace of the Byzantine Emperors, Second Report* (pp. 52-104). Edinburgh: Edinburgh University Press.

Yılmaz, M.D. (2021). *Parion Su Yolları (Temin-Dağıtım-Tahliye)*. (Doktora Tezi). Atatürk Üniversitesi Sosyal Bilimler Enstitüsü, Erzurum.