THE HADRIANIC AQUEDUCT

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ABSTRACT

Since prehistoric times, the city of Athens and the wider region of Attica did not contain many natural water sources so aquatic reserves were never adequate to meet the needs of residents, as these changed through time. The construction of aqueducts was part of a more organized effort to address the water needs of the Attica basin area since prehistoric times. A key step in developing the city's water infrastructure took place during the Roman occupation of Athens when the Hadrianic aqueduct and the Hadrianic reservoir were built. Construction began in 125 AD and was completed in 140 AD

The Hadrianic was underground with natural flow requiring a small and continuous slope along the aqueduct. Wells, communicated through the aqueduct, were placed at regular intervals.

The main branch of the aqueduct - the central part of the Hadrianic, consists of the main tunnel, approximately 20 Km which starts from the foot of Mount Parnitha in the Olympic Village and ends up in the reservoir of Lycabettus, exploiting the water sources of Parnitha, Penteli and the Kifissos River. Gravity collected water from the water sources in the main tunnel and there was also the contribution of smaller aqueducts along the route. The secondary branches are composed of many transverse, which were designed to increase the water discharge capacity of the main aqueduct.

The Hadrianic was a project of continuous multi source gathering the groundwater along its path. It was constructed below the surface at a depth of 2.5 to 40 m depending on the upper aquifer of the Athens basin, in order to utilize all available water resources in its path as well as the water from the groundwater wells.

The Hadrianic stopped being maintained during the Turkish occupation and returned into service after the liberation of the city until it was gradually abandoned after the construction of modern water resource projects

Keywords: Hadrianic, aqueducts, tunnel, wells, groundwater, water resources

1. Introduction

This study aims to highlight the bibliographic announcements and research and to add new map information regarding the route and hydrogeology of the Hadrianic aqueduct.

The main purpose of Hadrian's Aqueduct was not the water supply of ancient Athens as many think, but the water supply of the Roman district of Athens. Its construction coincided with a period of drought for Athens. The region of the ancient "City of Hadrian' 'started from Hadrian's Gate and covered all the area of the current Zappeio park, from the Kallimarmaro stadium till the parliament building. The Romans built many public baths and wealthy citizens required running water in their homes. The daily water consumption per capita increased to 70 liters in the case of ordinary citizens and 500 liters a day in the case of a Roman official. A new source of water had to be found.

2. Historical development of the Adrianic aqueduct

The construction of the water supply project for Hadrian's City from the slopes of Mount Parnitha and Penteli started in 125 AD. The project was a huge achievement for its time and constitutes one of the longest tunnels of the Roman era worldwide. This extremely expensive project was completed in 140 AD under the reign of Antoninus Pius. The Hadrianic supplied Athens with water for centuries and succeeded the late roman aqueduct.

The Hadrianic ceased to operate because of its abandonment during the dark ages, where in many places there were collapses and the pipes were blocked since maintenance, supervision and the cleaning services were non-existent. It was rediscovered in 1847 during works at the 'spring' of Ag. Dimitrios at Panormou street, Ambelokipi. The water found a way out because of the collapse of the tunnel due to blocked section within the Athenian Schists. Because of this, the necessary repairs to put the aqueduct back in service began. At the same time wells from which the Turks watered their fields in the area of Ampelokipoi were explored and it was found that they were connected with the ancient aqueduct. At the time, only 367 wells were found. The northernmost well is no. 367, using the old numbering convention in relation to the Lycabettus reservoir or no. 299 using the new numbering approach that uses Ag. Dimitrios in Ampelokipoi (Pappas, 1999). After the Asia Minor disaster (1922), Athens faced a sudden increase in population due to an influx of refugees. The population rose from 150,000 to 800,000 residents and the water supply situation deteriorated.

In 1924 the US company ULEN was awarded the Athens water supply project, providing for new water sources as well as a new water distribution system. The first concern of the company was to repair the Hadrianic aqueduct and improve its flow capacity. The aqueduct was recorded topographically, was cleaned, and was repaired across its entire length. 299 wells were recorded and numbered, all the way up to the edge of the main branch within the sloping tunnel. Moreover, major improvement projects were undertaken in order to increase the water gathering capacity of the aqueduct with wells and microdams at the springs of Kithara and Ampoli, at the area of Tatoi. There was also an extension of the ancient aqueduct branches for collecting water from the sources at Dimogli and Kokkinara (Kifissia). Following the improvements mentioned above, the Hadrianic was supplying water to Athens, for more than 1800 years after its construction, with an average of 2.8 million cubic meters of water a year! The aqueduct ceased to be the main source of water for Athens after the construction of the Marathon dam and the Bogiati tunnel in (1929). However it was used as an additional water source for many years after that. The aqueduct, hundreds of years after its construction, most likely includes partial gaps due to rockfalls, but still carries enough water to its end at Panormou street (Agios Dimitrios). The water then deflects into the Alexandras Ave. sewer system.

Today there are about 130 exposed wells in public areas or private properties. There may be more, covered with metal caps on certain roads. Although over the years the Hadrianic was overtaken by other water supply systems, it still provides water for certain uses. More specifically, it supplies the water treatment plant of EYDAP at Metamorphosis and it also supplies the municipalities of Metamorphosis and N. Ionia with water for irrigation. Additionally, in Metamorphosis, it also provides water to industry.

3. The tunnel of the Hadrianic aqueduct

The route of the tunnel was as follows: Starting from the reservoir at the foot of Lycabettus Hill, the tunnel headed to Ambelokipoi and from there followed the route of today's Kifissias Avenue, always underground. At the position Diavolorema near the Nursing Home, the tunnel followed an easterly direction until the circular tank of Halandri and from there it changed to a northwesterly path towards Heraklion and Koukouvaounes. From there, the tunnel headed down the Kifissos river and then passed from position Monopati arriving at the Souna (or Schinia) stream in Menidi. At that point, the underground pipeline was split in two, one part was directed north towards the Ampoli valley in the southern environs of the royal villa at Dhekelia and the other was directed west towards Holy Trinity of Parnitha, which is known for its rich aquifers and springs.
The width of the tunnel, varied from 70cm to 80cm and the height from 1.20cm to 1.60cm. It was constructed from bricks whose size varied depending on the dimensions of the tunnel and the

shape of the domes. (A. Kordellas, 1879). The incline of the tunnel changes across its length. Its northern part has an incline of ~ 2,5 ‰ for approximately1.5 Km and it is situated inside the talues cones and scree. The tunnel then becomes steeper for approximately 2.5 Km, with a slope of ~ 13 ‰ and passes under the bed of the river Kifissos in the area of Chelidonou. The tunnel's incline is then almost constant for its remaining path of 16Km, with a slope of ~ 2.2 ‰ from the underground junction with Kifissos until the tank at Lycabettus, (Chiotis, 2008).

The project was constructed by drilling 465 wells (10 to 42 m. deep) along the tunnel's designated route. The tunnel was dug out from pairs of neighbouring wells and the two sections met in the middle. The average distance between wells was 35 - 40 m. Many of the wells can still be identified today. The wells of the Hadrianic were at ground level and camouflaged in order to not be easily recognizable and to be protected from the risk of water pollution, natural disasters and enemy actions. They were accessed only when cleaning or repairs were required and also in order to allow sunlight access.

The tunnel made use of gravity to carry water into the stone reservoir at Lycabettus Hill (altitude of 136 m above sea level). From there, the water was distributed to the Roman district of Athens located at an altitude of 90 m. The original tank was 26m long, 9.36 m wide and 2m high. It had a capacity of 489 m3. Pipes originating from the reservoir supplied water to the city in large quantities, enough to cover the needs of the Athenians at the time. Leigh (1998), believes that the tank had a dual role and was also functioned as a nymphaeum. The face of the tank was adorned with four smooth Ionic columns that supported the epistyle, which featured an inscription in Roman letters commemorating the pioneers of this important project for the city of Athens. Nowadays, this inscription can be seen lying on the ground just above the statue of Eynard in the National Gardens.

The aqueduct approached the Market from the east at a higher elevation than other aqueducts along the road south of Eleusinion. It was a closed channel made out of bricks and had a vaulted ceiling. After passing under the Panathenaic Way it split into two branches; one turned west and the other north. The western branch of the aqueduct provided water to a channel that was found northwest of Areios Pagos and flowed towards Piraeus Street. The northern branch of the aqueduct was supported by arches and led to the 'Nymphaeum', north of the old Southeastern Fountain (Thompson & Wycherley, 1972, 202 Leigh, 1998, Chiotis, 2012)

4. Water resources of the Hadrianic aqueduct

As there are more extensive studies, there is an ever-increasing understanding and knowledge that the Hadrianic was a project of continuous, multi-source gathering water. It was constructed below ground at a depth of 2.5m to 40 m depending on the upper aquifer of the basin, in order to utilize all the available water resources and groundwater wells in its path. The tunnel is connected to the surface through a 90m long section built at an incline of 20o in order to collect water from the sources of the Parnitha Mountain. The end of the tunnel at the northernmost well is located 30.5m deep and the water level is currently 20 meters, as measured at a nearby drilling (Vrellis, 2010 Chiotis, 2012). These auxiliary aqueducts include the northern surface extension of the aqueduct towards Thrakomakedones and Varypompi, built to transport water from sources at Parnitha, as well as extensions of the tunnel with local aqueducts, to transport the water from the foothills of Mount Penteli to the tunnel. The recent archaeological excavations at the Olympic Village have brought to light parts of the aqueduct that were shown on EYDAP maps but were hidden beneath a layer of earth one to two meters thick. The excavations revealed the north surface extension of the Hadrianic which is now visitable (Platonos-Yota, 2004). Transverse aqueducts were: Halandri, Kalogreza, Brahami, Psalidi, Agia Barbara, Kaliftaki, Kefalari and Agia Kiriaki.

The most documented transverse aqueduct is the Halandri aqueduct that fed into well 102 in today's El Alamein street. It is believed that it flowed into a circular tank, from which the overflow was channeled to the Hadrianic. It carried spring water from the Penteli Mountain through the stream of Chalandri, starting from the Monastery of Penteli. The construction of several side branches of the aqueduct was made at different times but most of them were built using a similar approach. The project must have been even more complex in antiquity. (Kordellas, 1879)

considers that the project comprised of the northwestern tunnel and a direct water supply from the Kifissos river as well as of other branches.

The Hadrianic was dug out, as mentioned above, below the aquifer. The tunnel starts in fan at Thrakomakedones where the aquifer of the talues cones and scree found above watertight clay sediments. The burrowing must have taken place upstream in order to achieve natural drainage of the water, especially in the section from the junction with the Kifissos River up to the Olympic village. Drainage was not an issue in the area of the Athenian Schists however there were different concerns to do with the stability of the bedrock. Besides, the discovery of the Hadrianic is indirectly linked to the collapse of the tunnel section built in the Athenian Schists at Panormou Street, in the area of Ag. Dimitrios in Ambelokipi. The tunnel is connected to the surface through a 90m long section built at an incline of 20o in order to collect water from the sources of the Parnitha Mountain. The end of the tunnel at the northernmost well is located 30.5m deep and the water level is currently 20 meters, as measured at a nearby drilling (Vrellis, 2010 Chiotis, 2012).

5. Conclusions

The Hadrianic supplied water to Athens for more than 1800 years, making use of the water resources of Parnitha and Penteli as well as the fact that it was constructed below the level of the aquifer. It constituted a tunnel of continuous, multi-source gathering water. The research related to its water sources and the different sections of the aqueduct is still in progress as we currently do not have a full picture of the aqueduct. Kordelas' (1879) writings, descriptions of technical projects in modern times as well as recent archaeological discoveries in the Olympic Stadium area, suggest the existence of aqueducts preceding the Hadrianic as well as more recent infrastructure works carried out by the municipality of Athens. All of these were fed and are still fed by the same sources.

The path of the Hadrianic, the depths of its tunnels and the positions of its auxiliary aqueducts reveal that the Hadrianic was the largest and most important water supply project in Athens in historical times. A project of a sophisticated technological and hydrogeological culture. It is perhaps one of the most unique technical projects with continuous use over 2000 years and should been promoted in a way that would benefit modern Greeks and infuse their patriotism and national pride. According to EYDAP, Greece should promote this project with photographic exhibitions, scientific discussions and other such events and not let it be lost in time. The aims of EYDAP are to:

- explore the Hadrianic as a whole and to record its current condition
- photograph and video of the interior of the aqueduct.
- assess the current flow capacity and evaluate the quality of the water it transfers and
- examine the current irrigation opportunities in areas such as the Olympic Stadium or the City of Athens in order not to waste the water provided by the aqueduct.

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