ARQUEOLOGÍA DE LA ARQUITECTURA, 15,
enero-diciembre 2018, e069
Madrid / Vitoria
ISSN-L: 1695-2731
https://doi.org/10.3989/arq.arqt.2018.004

ESTUDIOS / *STUDIES*

The water collecting system of the Sete Fontes, Braga (4th-20th century)

El sistema de captación de agua de las Sete Fontes, Braga (siglos IV-XX)

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ABSTRACT
The collecting, conveying and use of water to serve the city of Braga was, over centuries, one of the elements that deserved special attention from the city governors, who wisely invested in the construction, expansion and maintenance of the hydraulic system, of which complexity and quality were maximized by building the hydraulic system of Sete Fontes (Seven Fountains), located about 5 km from the city centre. The archaeological work undertaken by the Unit of Archaeology of the University of Minho, between 2012 and 2015, allowed to significantly increase the knowledge of the constructive and architectural characteristics of these hydraulic structures which preserve elements of Roman, medieval, modern and contemporary times. It provides thus a unique testimony and example of the hydraulic engineering solutions and their constructive and architectural expressions in the long term, allowing us to call it a rarity in Portugal.

Key words: City of Braga; hydraulic engineering; building systems; Archaeology of Architecture.

RESUMEN
La captación, conducción y utilización del agua para el servicio de la ciudad de Braga constituyó, a lo largo de siglos, uno de los elementos que mereció especial atención por parte de los gobernantes de la ciudad, que sabiamente invirtieron en la construcción, ampliación y conservación del sistema hidráulico, cuya complejidad y calidad se maximizó en la construcción de las Sete Fontes, ubicadas a unos 5 km del centro urbano. Los trabajos arqueológicos allí realizados por la Unidad de Arqueología de la Universidade do Minho entre 2012 y 2015 permitieron incrementar significativamente el conocimiento de las características constructivas y arquitectónicas de las estructuras hidráulicas del sistema de captación de las Sete Fontes, que conserva elementos de época romana, medieval, moderna y contemporánea, constituyendo un testimonio singular y con carácter de ejemplo de las soluciones de ingeniería hidráulica y sus expresiones constructivas y arquitectónicas, de larga duración, pudiendo afirmarse que constituye una rareza en Portugal.

Palabras claves: Ciudad de Braga; ingeniería hidráulica; sistemas constructivos; Arqueología de la Arquitectura.

Recibido: 04-07-2017. Aceptado: 19-09-2017. Publicado online: 13/07/2018

Cómo citar este artículo / Citation
Fontes, L., Andrade, F., Pimenta, M. y Guerreiro, M. 2018: "The water collecting system of the Sete Fontes, Braga (4th-20th century)", *Arqueología de la Arquitectura*, 15: e069. https://doi.org/10.3989/arq.arqt.2018.004

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INTRODUCTION

This work is a first overview of the results obtained with the archaeological research carried out in the area of the Water Collecting System of Sete Fontes in São Victor, Braga, in the *Preliminary Study of the Detail Plan of Sete Fontes*, promoted by the Municipality of Braga.

Under the scientific direction and overall coordination of the signatory, the execution of the work was undertaken by a team of 7 archaeologists and 1 technician (Bruno Osório, Francisco Andrade, Juliana Silva, Luís Silva, Mafalda Alves, Mário Pimenta, Maurício Guerreiro and Eurico Machado) and also with the cooperation of the municipal officials Joaquim Peixoto and Manuel Fernandes, excellent connoisseurs of the Sete Fontes system and to whom we owe, for the professionalism and dedication, its conservation.

The archaeological intervention was determined by the recognized archaeological sensitivity of the hydraulic complex of the Sete Fontes and its surrounding, as it was held a first assessment of the previous study of the detailed plan by the Regional Directorate of Northern Culture / MC-DRCN, which conditioned its approval to the prior execution of archaeological studies.

This heritage was classified in 2011 as National Monument and it should be noted that the set of the Sete Fontes water collecting structures provided for the public water supply system of the city of Braga until the first half of the twentieth century, and is still active today (Martins, Meireles, Fontes, Ribeiro, Magalhães and Braga 2012). The system's origin dates back to the Roman period, having been well documented since the late Medieval Ages. It was substantially expanded between the seventeenth and nineteenth centuries, standing out the reformations performed on the first half of the eighteenth century for their distinguishing features of Baroque architecture.

METHODOLOGICAL NOTES

The archaeological study included topographic and architectural surveys of the structures that make up the hydraulic system, including the survey of its elevation profile. In addition, 13 archaeological trial trenches were excavated, their dimensions and location were predefined by the archaeological team, being implanted on the contiguous terrains or directly on the collecting and conveying structures of the hydraulic system.

Topographical and full architectural and detailed survey drawings of the layout and structures that make up the collection and transport system in the study area were undertaken, resulting in a wide collection of drawings: plans, elevations, sections and cuts (to a 1:20 or 1:50 scale). The drawings were handmade on graph paper and/or automatically with an EDM/Total Station. All raster images were traced into vector drawings and compiled in a single complete map of the site, georeferenced to the ETRS 89_TM06 coordinate system (Transverse Mercator projection). These surveys were complemented with a detailed and comprehensive photographic record.

Taking into account that the terrain which was object of study was used until less than a decade for cultivation and therefore the sediments appear mixed, resulting in a heterogeneous, complex stratigraphy, combined with the fact that the surface prospection did not provide any indicators of the existence of surface archaeological remains, the initial layer of agricultural soil was removed with mechanical means, under the direct guidance of the archeological team.

When sedimentation and/or structures of archeological interest were identified, these were manually excavated according to the principles of stratigraphic excavation, using a backward chronology technique, as the sediments are removed from the newest to the oldest. The sediments and archaeological structures were identified as Stratigraphic Units (SUs), sedimentary and constructed, which were systematically recorded in standardized forms, drawings (plans, cuts and elevations) at the appropriate scales and in a photographic record. When it was considered appropriate, drawings by convergent photogrammetry were made and added to the graphic record.

THE SITE OF SETE FONTES: GEOLOGY AND HYDRODYNAMICS

The site of the Sete Fontes corresponds to an *alveolus* in the foothills at the western edge of the Mountain of Carvalho, being dominated at the top, to the north, by the hill of Pedroso (332 meters) and the elevations of Montariol (312 meters) and Barros (289 meters), respectively to the northwest and southeast. The *alveolus* of Sete Fontes draws a small basin where confluent small water lines that at the approximate altitude of 245 meters originate the brook of Passos or Goladas, that flows further south into the Este river (Fig. 1).

A significant part of the area coincides with a Paleozoic metasedimentary region, embedded in the northeast by the Hercynian massive granitic protrusion of 'Sameiro', which emerges in the Pedroso Hill. It is therefore a contact zone of different rock formations, consequence of several structural accidents resulting in shearing with dominant direction NW-SE and intense fracturing with dominant guidelines NW/SE, N/S and SW/NE (Ferreira, Dias, Meireles and Braga 2000: 8-12 and 40-42) (Fig. 1).

Considering the data related to precipitation (annual average = 1515mm) and evapotranspiration (annual average = 610mm), the calculation of water balance shows a real annual average evapotranspiration of 515mm and a water surplus or debit surface flow of 989mm, which means an annual average rate of infiltration of 1.3%. As the permeability of the rock formations in this region is generally medium to low, the productivity of the flow collections is also reduced, registering values ranging between 0.3 l/s and 3 l/s per km^2 (Ferreira, Dias, Meireles and Braga 2000: 44-45), i.e., very little water is kept underground. However, in the rock formation contact zones and places of wider fracturing, such as the area of Sete Fontes, there is a greater permeability and higher productivities, with collections flowing up to 3 l/s (Ferreira, Dias, Meireles and Braga 2000: 44-46).

Based on data from the hydrological year of 2011-2012 it is assumed, for the area of Sete Fontes (905252 m^2), an average rainfall of 1674.1mm and a 23% of groundwater recharge, estimating the total renewable groundwater resources annually at 3.5* 105 m^3/year. In this same period (a dry year), the overall productivity of the system, with a seasonal variability ranging from 271.3 m^3/day minimum and 1183.4 m^3/day maximum flow, presented an average of 574.4 m^3/day, values which may be substantially exceeded in an average year and more in a humid year (Rodrigues 2012: 182)[5].

We are thus faced with the area, in the surroundings of the city of Braga, which has the most favorable hydrogeological conditions for the existence of aquifers and in this sense, the choice of this location for the establishment

[5] Rodrigues, M. 2012: *Hidrodinâmica do Sistema de Captação das Setes Fontes: Contributo para o Ordenamento do Território do Município de Braga (Hydrodynamics of the Collecting Water System of Sevens Fountains: Contribution to the Spatial Planning of the Municipality of Braga)*. Master thesis, University of Minho. Braga, Portugal.

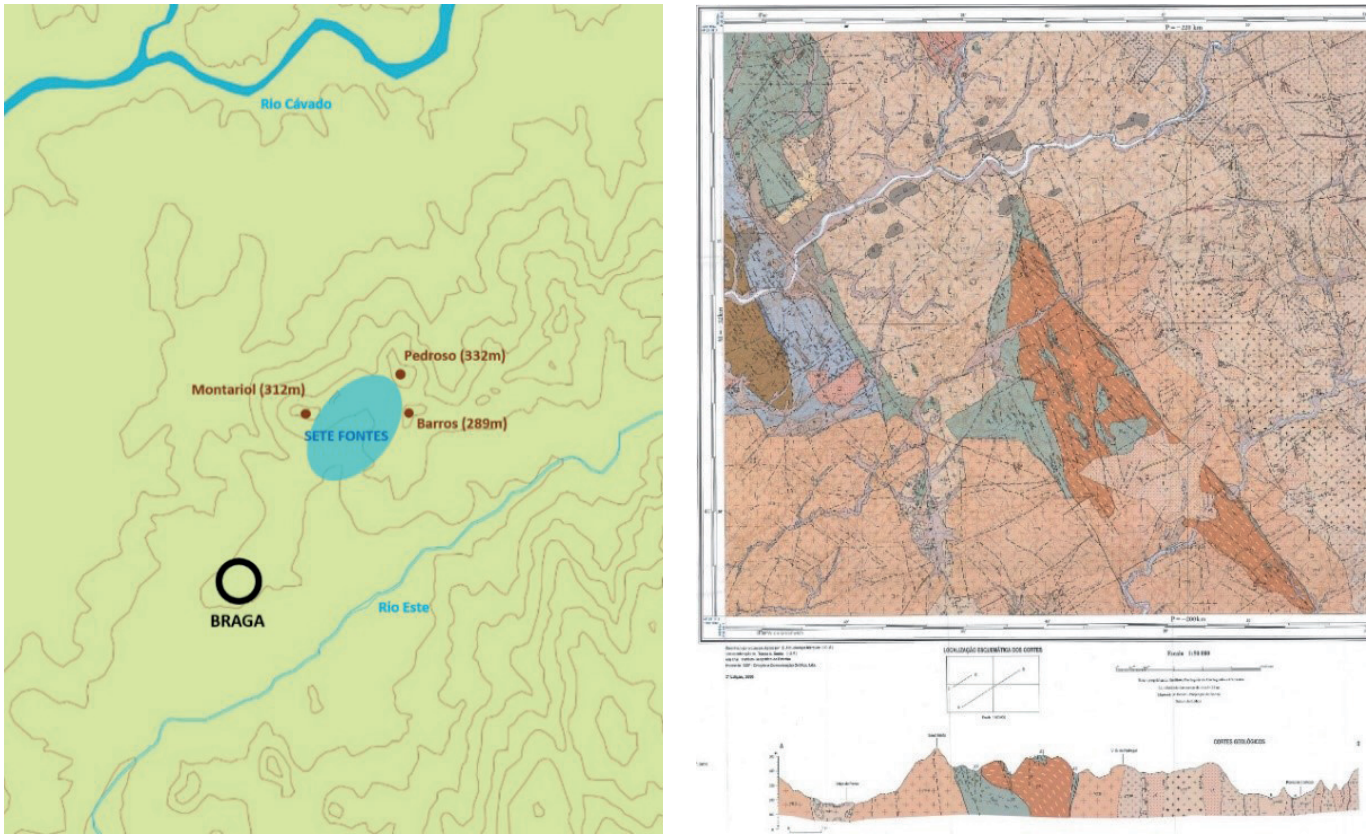

Figure 1. Orography, Hydrography and Geology of the Sete Fontes area (Extract from Sheet 5d BRAGA, the Geological Map of Portugal. IGM/DG).

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of the city surely took into account the availability of water in the vicinities. Although being about 5 km away, the choice of the Sete Fontes area for collecting the water supply to the city of Braga has also taken into account the fact that its transport can be made simply by using the force of gravity, knowing the maximum altitude of the city does not exceed 199 meters and the elevations in the Sete Fontes basin range from about 220m to 270m above mean sea level.

On the other hand, the surrounding landscape of the Sete Fontes has lost most of its former rural occupation. In fact, during the second half of the twentieth century, particularly in the last quarter, the city of Braga suffered a strong process of urban growth, which absorbed the outlying parishes, virtually spreading to the entire county. The same happened in the area of the Sete Fontes, which is no longer an area of farms. The surrounding is taken by urbanization, social, commercial and industrial equipment and the remaining agricultural fields of the old farms are abandoned. The flow and seepage of rainwater are deeply changed, and potential sources of pollution have multiplied.

THE COLLECTING SYSTEM AND ITS EVOLUTION

In the current state of conservation, the whole water collecting system consists of underground galleries, springs or heads of water and pipelines, with an approximate length of 3,600 meters, 2250 meters of which are underground galleries and the rest are stone pipelines or iron pipes. The most visible structures of this system are the small circular plan and vaulted ceiling buildings, which house galleries and pipelines connection basins.

The analysis of the constructive stratigraphy allowed the establishing of the evolutionary sequence of the Sete Fontes water collecting system, confirming its origin in Roman times, its enlargement in medieval times and its full consolidation during the eighteenth century.

Description

The characterization of the structures that make up the Sete Fontes collecting system was made according to the following definitions, already adopted in our previous study (Fontes 2012):

- Main Pipeline (CP): is the pipe/tube/main channel, underground or aerial, which receives water from several mines and boxes and leads it to the city;
- Reception and Settling basins (CX): are structures in the form of tanks in that receive, decant and lead water, locate directly in the main pipeline, or in the mines and secondary pipelines. They can be opened or closed structures being covered or not by underground and/or exterior constructions;
- Heads of Water (MA): structures that house the springs, conducting their water through the secondary pipes to the main pipeline. They are sheltered by underground and/or exterior vaulted buildings;
- Mines (MI): underground galleries dug in the geological substrate which penetrate the hillside, capturing water from aquifers and/or heads of water, carrying it through pipelines and secondary basins to the main pipeline.

The main pipeline (CP) is composed of granitic pipes with cylindrical longitudinal inner perforation with 0.18/0.22 meters in diameter and a 'male-female' joint type. With dimensions ranging between 0.52/1.67 meters long by 0.39/0.60 meters wide, the granitic pipes are carved out of parallelepipedic blocks, squared and cut using wooden wedges, as shown by the negative of the corresponding cavities preserved in some of the blocks (Fig. 2).

These roughly squared blocks have dressed faces, and in 7.5% of the granitic pipes it was identified the existence of decoration, using the technique of bossage, in which one or more faces present a roughly-finished protruding centre with a flat faced frame. The upper faces, next to its upstream side, have a rectangular perforation with about 0.18 x 0.12 meters, with a granite stone that served as a stopper. Currently, these perforations are sealed with cement, but when the system was in full operation they served to periodically clean debris accumulated inside the pipeline.

It is a sub aerial aqueduct, either supported by a uncoursed random rubble masonry wall, or partially buried only having its upper faces visible on the surface, which is also the case of the side supporting walls (built in granite and schist masonry) that exist in some portions of the pipeline and are partially buried (Fig. 3).

Along its route, the water collecting system incorporates numerous reception and decantation basins (CX). Inside the mines, placed longitudinally or transversely on the secondary pipelines, these basins are predominantly square or rectangular shaped, composed of monolithic granite tanks with dimensions not exceeding 1 meter on the side and 0.50 meters deep, sometimes covered by a granitic slab.

Figure 2. Detail and partial view of the main pipe section (CP). © UAUM

Figure 3. Survey drawing plan of the CP14 section of the main pipe. © UAUM

But the main system's basins are located on the main pipe, outwardly monumentalized as small buildings, commonly referred to as "chapels" (Figs. 4 and 5). Presenting a circular plan and a domed cover, with diameters and heights that reach 5 and 8 meters, respectively, these buildings house tanks of reception and decanting, composed of monolithic granite pieces, circular in shape, reaching 1.30 meters of diameter and 0.66 meters in depth. These tanks at collect and route the water brought by aqueducts of the most part of the mining system to the main pipe, also giving access to the entry of galleries in some of these mines.

The heads of water of the Sete Fontes collecting system are composite structures, entirely subterraneous, formed by a circular, rectangular or trapezoidal plan chamber, with or without a ventilation chimney, located on water springs that flow from rock fractures.

Heads of water with ventilation chimney have two subtypes. The MA.1 is a circular chamber 2 meters in diameter, which rises in the cylinder shaped plan about 9 meters to reach the surface, fully built in cyclopean granite masonry. It is finished on the exterior by an octagonal chimney that has 4 meters in height, with a perforated prismatic cover, also built in granite stonework (Fig. 6). The MA.2 and 3, fully built in granite stone mounted random coursed ashlar masonry are also circular chambers with diameters exceeding 3 meters and hemispherical domed roofs up to about 5 meters high. The vaults are open to the centre, receiving a cylindrical chimney with about 1 meter in diameter, which rises about 4 meters above the surface, ending in a horizontal cover also with perforations.

The heads of water without ventilation chimney are quadrangular and/or trapezoidal chambers, with cyclopean masonry walls of granite and schist and horizontal ceilings formed by large granite monoliths, supported by pillars, also constructed with granite (except for the head of water from Dr. Amorim Sul - MA.6, which has a hemispherical dome ceiling) (Fig. 7).

The mines (MI) are underground galleries that, from the surface, penetrate the slopes spreading through variable lengths, the longest of which extends for about 400 meters (Órfãos's mine - MI.5), and also variable depths, as the Pretas's Mine (MI.2), for instance, ends more than

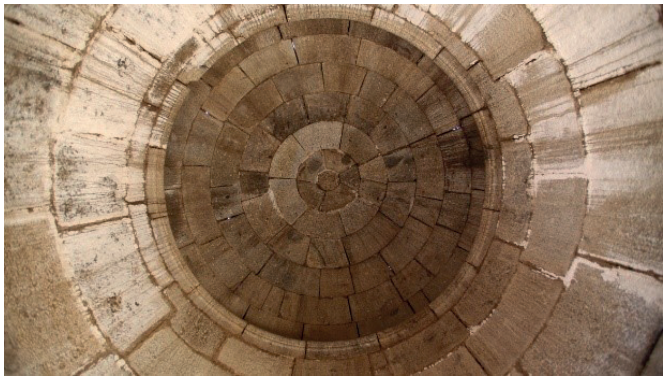

Figure 4. Overview and details of the Dr. Sampaio's settling basin (CX 12). © UAUM

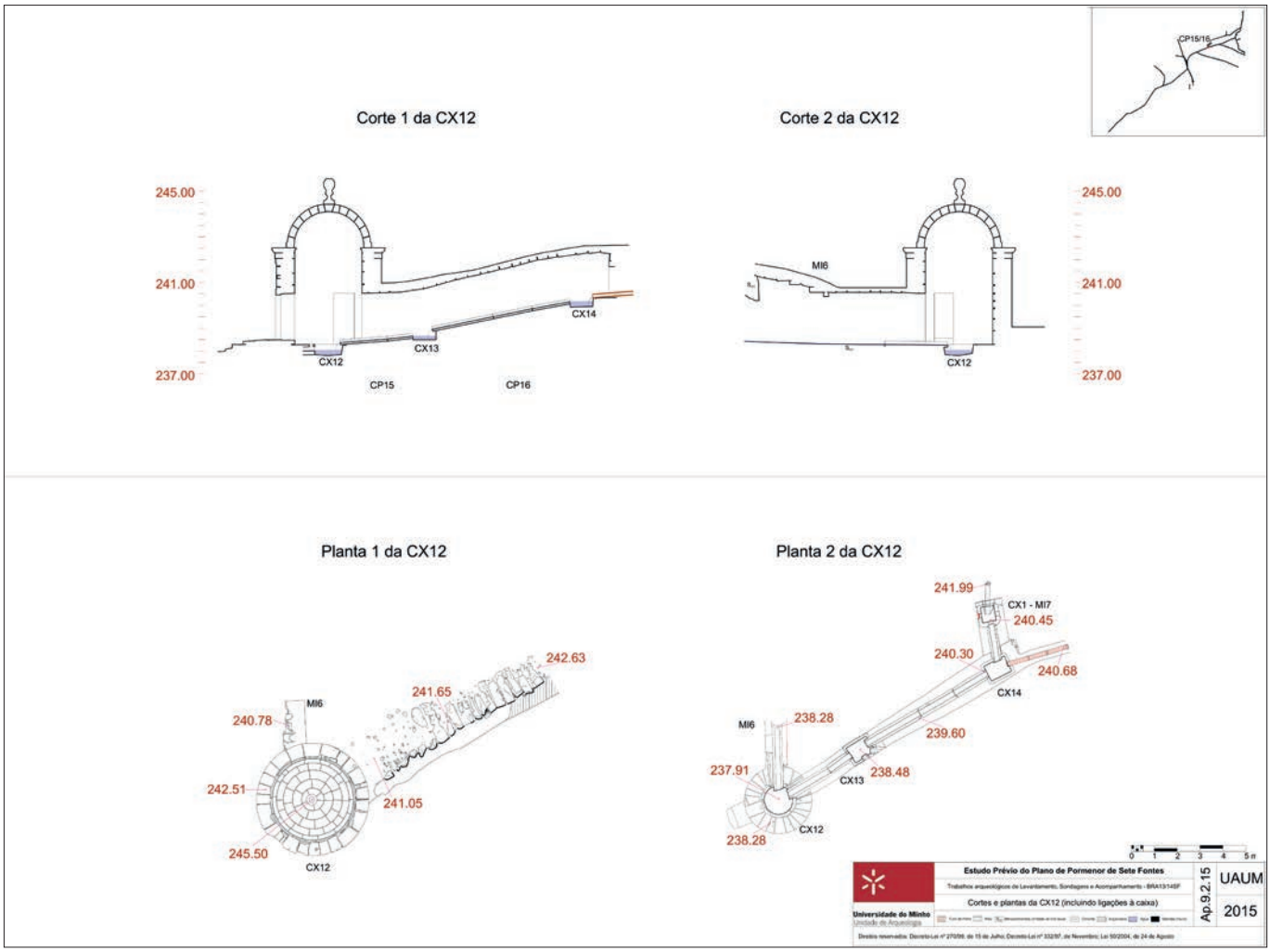

Figure 5. Elevations and plans of Dr. Sampaio's settling basin (CX 12). © UAUM

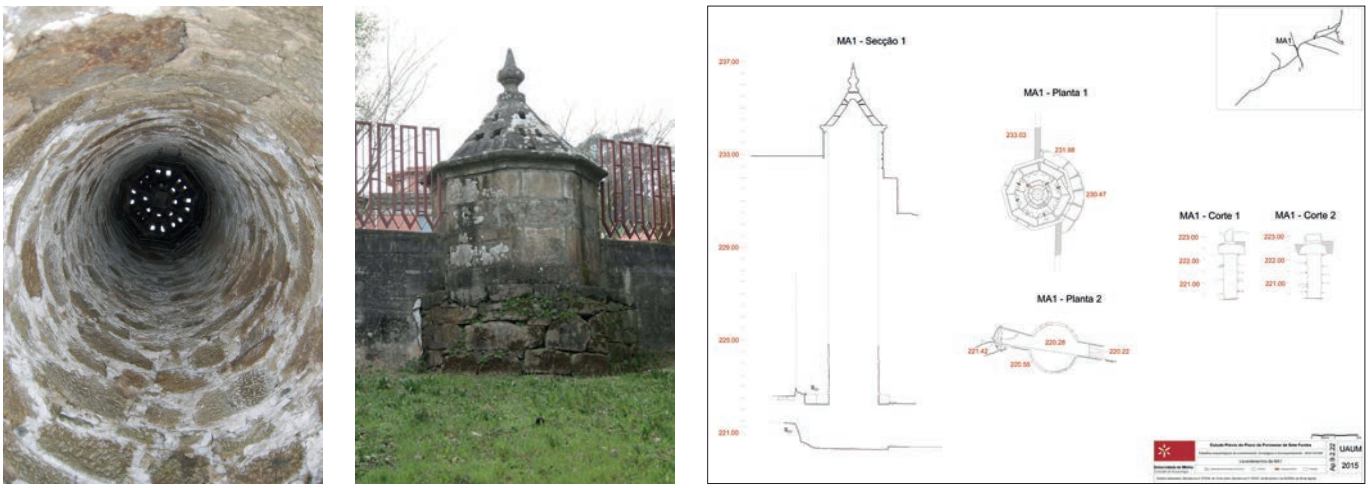

Figure 6. Freiras's head of water (MA.1) - Exterior and interior view; elevations and plans. © UAUM

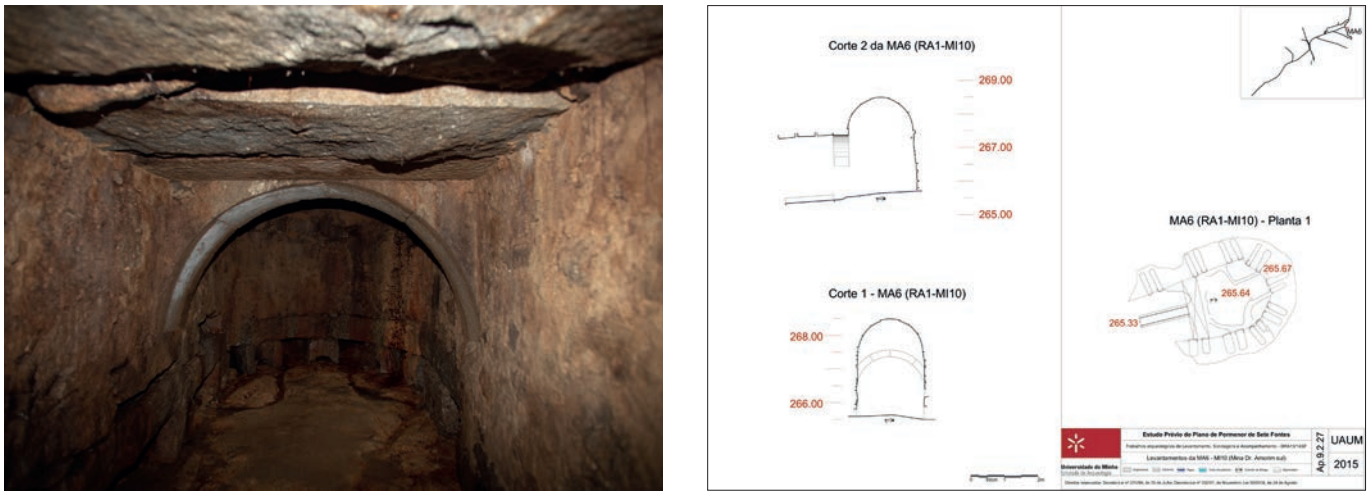

Figure 7. Dr. Amorim Sul's head of water of (MA.6) - Interior view; elevations and plan.© UAUM

20 meters below the surface. In somewhat regular intervals, vertical ventilation wells connect the mines to the surface (Fig. 8).

In the schist areas the galleries are structured with uncoursed random rubble granite and schist masonry walls with a flat ceiling composed of granite slabs, drawing rectangular sections. In granite areas the galleries have walls and ceiling without any coating, drawing sections of variable form, determined by the hardness of the rock. The water collected along the path of the mines runs directly on the bedrock or aqueducts composed of granite gutters and/or small tile channels, being conducted to the various receiving and settling basins that connect to the main pipeline (Fig. 9).

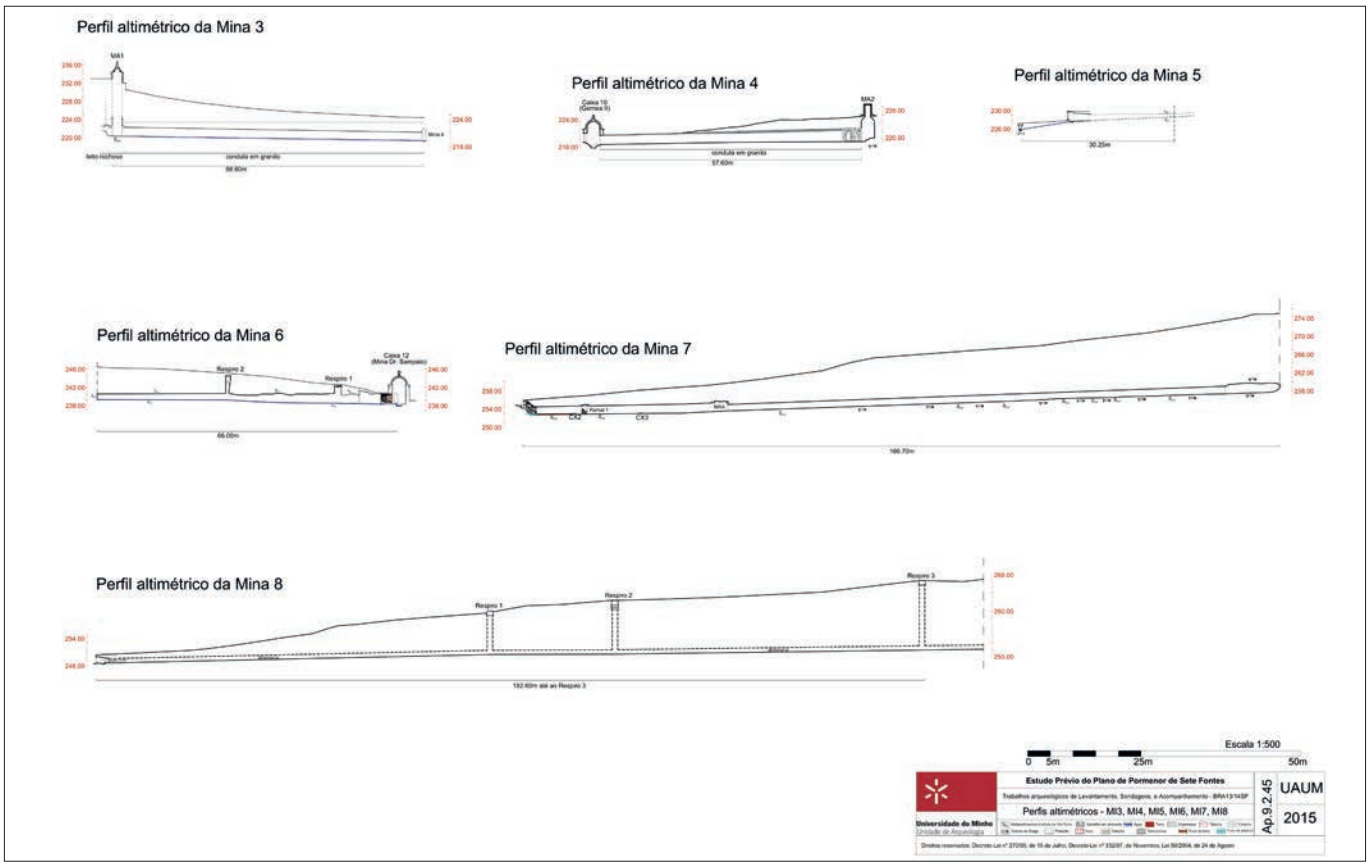

Figure 8. Altimetry profiles of some of the mines of the Sete Fontes collecting system. © UAUM

Figure 9. Details of the entry of the Dr. Nozes's mine (MI.8) and the Preta's mine section (MI.2) in the transition from schist to granite. © UAUM

Chronologies

Phase I (pre-fifteenth century) - The analysis of the constructive stratigraphy allows us to say that the longest section of the main pipe (CP) corresponds to the oldest part of the system. However, the data from archaeological excavations and documentary analysis only allows us to propose a relatively wide chronological line that possibly extends from as far the fourth century between to the end of the fourteenth century (Fig. 11).

For the upper limit of medieval era (pre-fifteenth century), contributes the fact that the relative and/or absolute chronology established for the construction sequence of the system determines that this part of the main pipeline is prior to the fifteenth century, a statement corroborated and further explained on the paragraph describing what is considered by us as Phase II.

For the lower limit of the Roman era (fourth century), which is the scarcer when talking about physical or documentary evidence contributes the archaeological context, the fact of not having identified any previous anthropic sedimentation in the installation of the pipeline and its constructive typology, especially the modulation of the granitic pipes that make up the stone conduit. Indeed, the dimensions of the granitic pipes bind to the Roman module of the *Pes*/feet (0.2957 meters), their multiples and submultiples, with the mode of 1.23 meters in length and the corresponding width of 0.50 meters, or as in the Roman metric system, 4 *pes* and 1 *palmus* by 1 *pes* and 3 *palmus*.

Phase II (fifteenth century) - This phase is represented by the mine designated branch RA1of the head of water MA1 and by the MI6 mine, which will connect to the CX12 (Fig. 11). As follows from the relations established by the analysis of constructive stratigraphy, it was necessarily constructed before the second half of the sixteenth century. In the absence of archaeological data that allow us to clarify its chronology, we have turned to archival records to locate its construction in the fifteenth century, in the

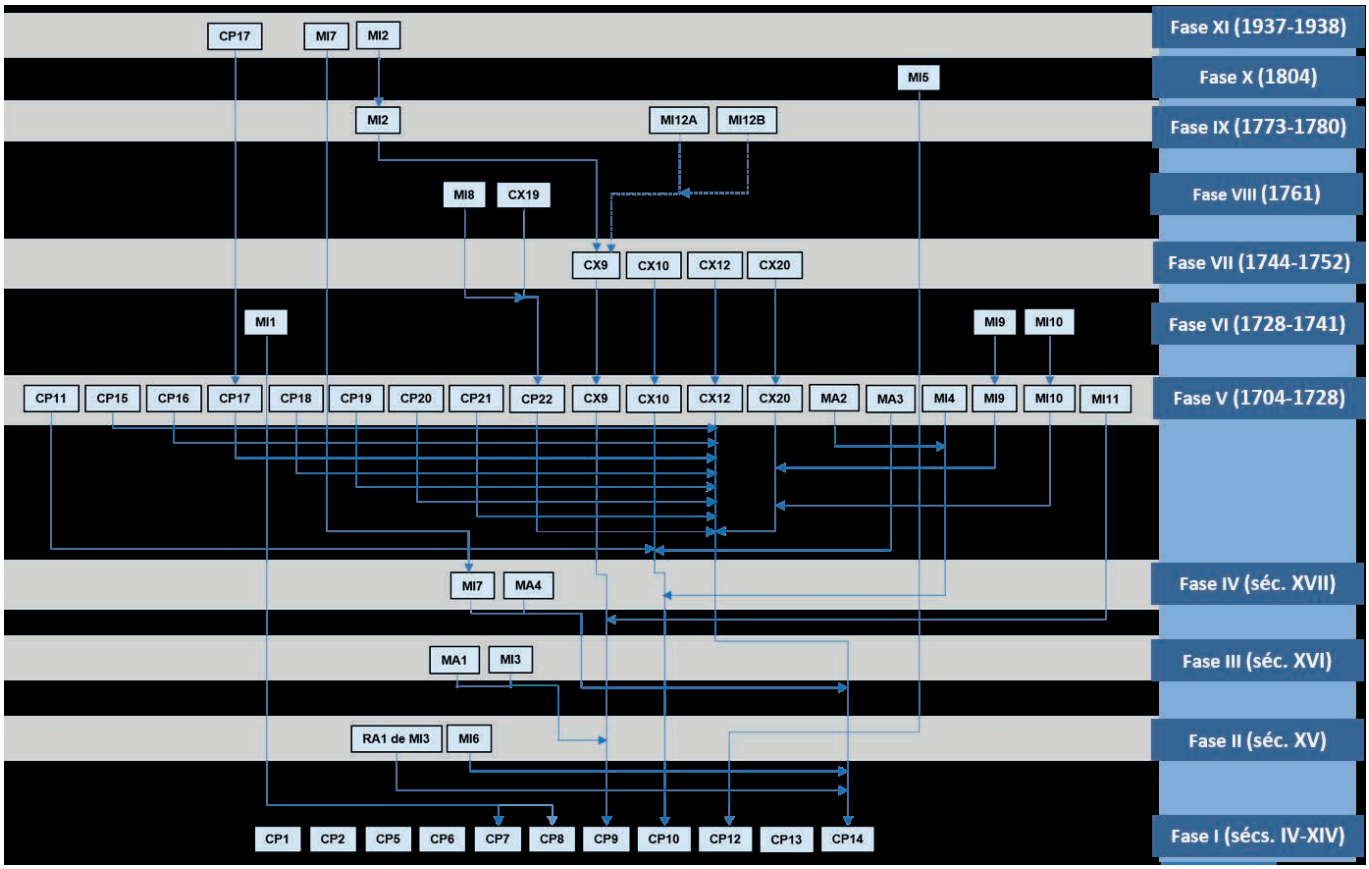

Figure 10. Diagram of the construction sequence of the Sete Fontes's water collecting system. © UAUM

context of the major investments made by the Archbishop D. Fernando da Guerra (1417-1467) in the water supply of the city of Braga, around 5 km from the city, as it was highlighted by José Marques (Marques 1980: 127-138).

Phase III (sixteenth century) - Built at the same time, the head of water MA1 and the MI3 mine are under the stratigraphic relationships, subsequent to the structures referred to in the previous phase, dating from the fifteenth

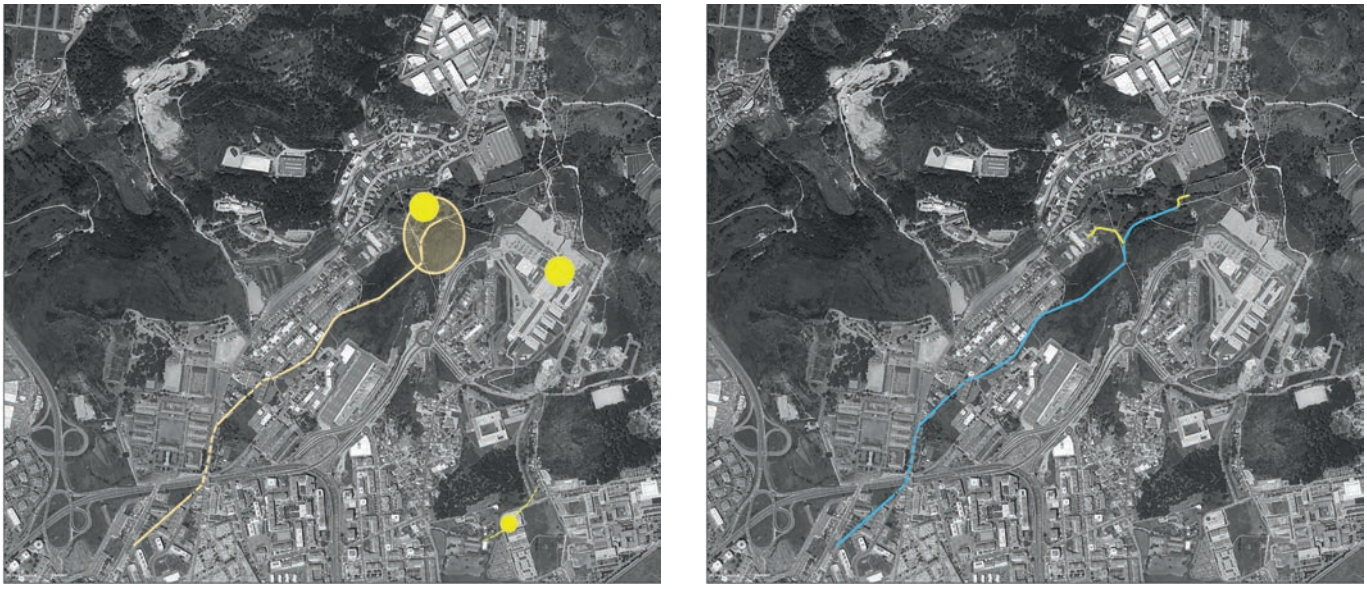

Figure 11. Cartography of Phases I and II of the Sete Fontes's water collecting system. © UAUM

century, and prior to the remodeling associated with the construction of head of water MA2 and MI4 mine, their chronology does not exceed the first quarter of the eighteenth century. But here we benefit from an additional typological data, provided by the architectural style of the MA1 ventilation chimney, whose prismatic form reveals a clear Renaissance feature that allows us to point out the second half of the sixteenth century as the probable construction period, coinciding with the time that the city of Braga met great new buildings, under the rule of the Archbishop D. Frei Bartolomeu dos Mártires (1559-1582) (Fig. 12).

Phase IV (seventeenth century) - In our proposal for a constructive sequence of the Sete Fontes follows the Pópulo's Mine (MI7), part of the head of water MA4. In addition to the stratigraphic construction sequence evidenced by archaeological analysis, which determines its posterity in relation to the MI6 and prior to the great works of the first third of the eighteenth century, archival sources allow to place the construction of these structures of 'Pópulo' in the early seventeenth century, correlating with the construction of the Pópulo convent, founded in 1596 at the initiative of Archbishop D. Frei Agostinho de Jesus (1588-1609). The association between the construction of new facilities in the city of Braga and the expansion of the water collecting system in the Sete Fontes, which is already implicit in the earlier stages, finds in the construction of this mine of Pópulo the first and most obvious testimony (Fig. 12).

Phase V (1st quarter of the eighteenth century) - This phase, represented by sections of the main pipeline CP11 and 15-22, the basins of Dr. Alvim de Baixo e de Cima, Dr. Sampaio and Dr. Amorim (CX 9, 10, 12 and 20), the head of water of Pinheiro de Cima and Órfãos (MA2 and 3), the mines of Pinheiro de Cima e de Baixo and initial sections of Dr. Amorim north and south mines (MI4 and 11 and the early part of MI9 and 10) corresponds to the broader renovation and expansion of the water collecting system of the Sete Fontes evidenced by the stratigraphic-constructive archaeological analysis in this study (Fig. 13).

The timeline for this phase is relatively established from the stratigraphic relations with the structures that are part of the earlier and later stages and absolutely based on numerous archival references, whose critical reading allowed us to correlate the descriptions that provide the size of the building works performed and with the constituent elements of the structures, in particular the water houses. In fact, it is in the first quarter of the eighteenth century that the opening of the mines is documented for the area of the Sete Fontes, construction of pipes and water houses as well as the respective road access. This construction phase coincides temporally with the mandate of D. Rodrigo de Moura Teles (1704-1728), who applied the significant amount of *2,400$000 réis* exactly in city water conveying works and sidewalks.

Phase VI (1728-1741) - The extensive renovation program and expansion of the water collecting system of the Sete Fontes implemented by D. Rodrigo de Moura Teles was continued by the Senate of the City Chamber in the period immediately following the death

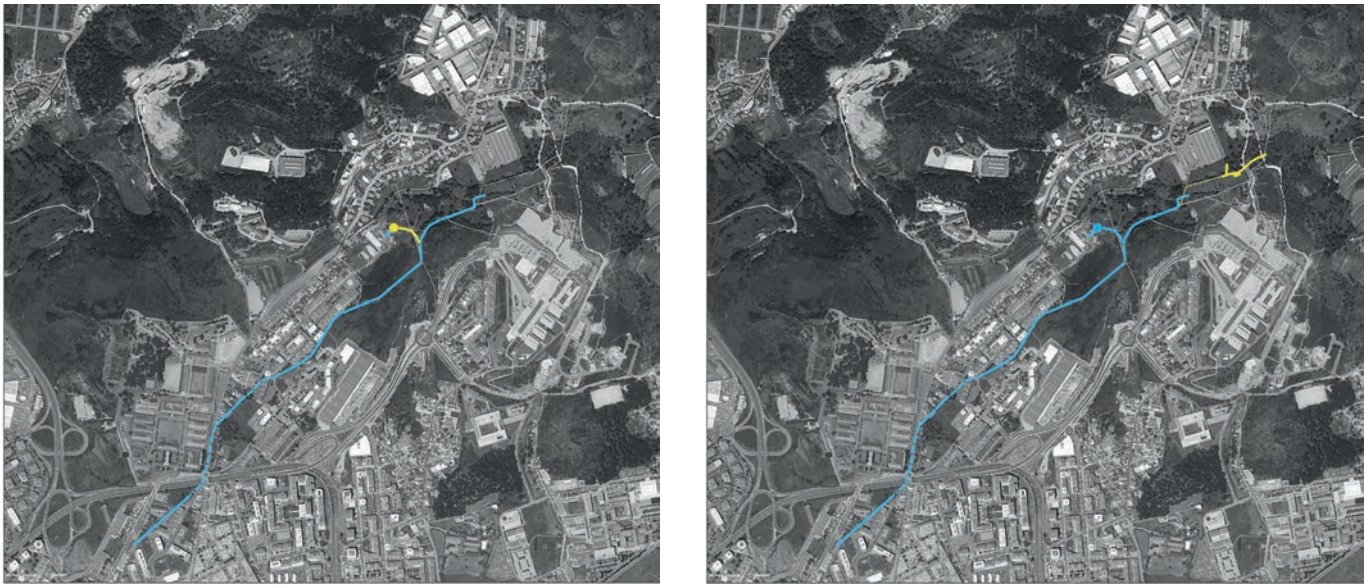

Figure 12. Cartography of Phases III and IV of the Sete Fontes's water collecting system. © UAUM

of this prelate, despite the head of the episcopal church of Braga being in *sede vacant*. As in the previous stage, the municipal archives register for this times several works in new water collecting sites and the construction of conduits leading to existing basins and aqueducts, for which there had indeed been a budget increase through granting of the remains of a conveyance tax given by the King D. João V in 1731 (Fig. 13).

For the identification of the structures included in this phase, the final sections of the mines Dr. Amorim north and south (terminal part of MI9 and 10) and the mine of Chedas (MI1), was particularly helpful the description contained in the measurement auto of the modern Caixa de Águas (*Castellum Divisorium)*, held on June 6, 1737, which specifies that new mines were opened, and the stratigraphic constructive relations evidenced by these structures are consistent with the timeline indicated.

Phase VII (1744-1752) - This phase corresponds to the completion of the work initiated in the two previous phases, marked by the inscribed dates on the facades of the basins 9, 10, 12 and 20, in the first two 1744 and the others 1752. D. José de Bragança, the archbishop of Braga at the time, used the opportunity to mark the ownership of the water collecting system and to propagandize his landlord's management of Braga, placing carved granite stones with his coat of arms on the facade of the first and last basins, respectively CX9 and CX20 (Fig. 14).

Phase VIII (1761) - This phase, represented by the MI8 mine (Dr. Nozes) and its connection to the main pipeline through the CX19 basin that was rebuilt for the purpose, is easily dated in the year 1761, as the inscribed date on the memorial panel that overshadows the entrance of the already mentioned basin 19. In addition to noting the continuous gathering of the water in Sete Fontes, these structures mark the beginning of the expansion of the system to the southern side of the alveolus, implemented during the government of D. Gaspar de Bragança (1758 -1789) (Fig. 14).

Phase IX (c.1773-1780) - The mines MI2 (Preta or Lavarincho) and MI12A-B (Verdosas), were built in the last decades of the eighteenth century, as documented in municipal records. Except for Preta's mine, which seems to correspond to the need to improve the use of water infiltration in the central area of the northern slope, the Verdosas's mines satisfy the continuity of the program started in the previous phase of exploring the southern slope waters, which in 1789 would have been considered complete, since on that date it was put a mark at the beginning of the collecting area, prohibiting the opening of new mines and piping (Fig. 15).

Phase X (1804) - The mine of the Órfãos (MI5), which also explores the southeast side of the alveolus, is the last water collecting structure to be built in the Sete Fontes system. Dated of 1804, as the epigraph engraved on the lintel of the entrance door, this mine intended to supply, through the distribution network originating in Sete Fontes, the huge Seminary of S. Caetano (or Colégio dos Órfãos), constructed in 1791 by the Archbishop D . Frei Caetano Brandão (1790-1805) (Fig. 15).

Once again it shows the correlation between the construction of large facilities in the city of Braga and

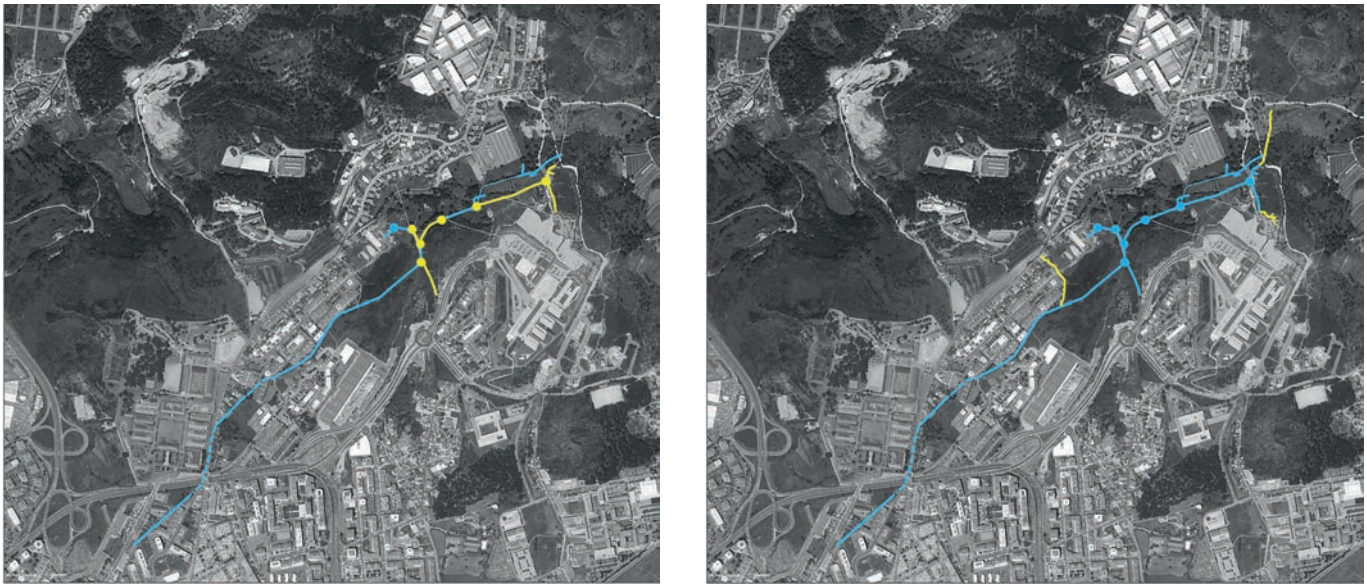

Figure 13. Cartography of Phases V and VI of the Sete Fontes's water collecting system. © UAUM

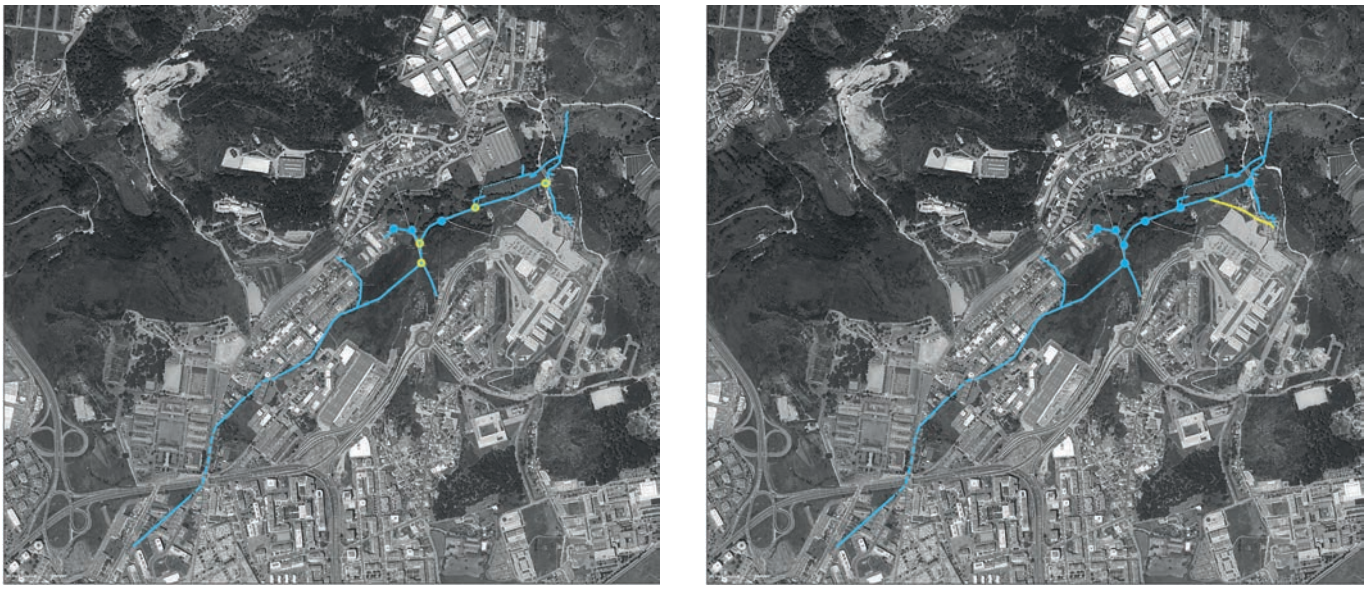

Figure 14. Cartography of Phases VII and VIII of the Sete Fontes's water collecting system. © UAUM

the corresponding increase/expansion of the collecting system in Sete Fontes, with the curiosity that in this case, the prohibition of 1789 was exceeded.

Phase XI (1937-1938) - This phase corresponds to refurbishments made in 1937-38 in the collecting and water supply system from Sete Fontes, following the "Water exploitation project of Mines of the Seven Fountains", then promoted by the Municipality of Braga to strengthen the water supply to the city.

Designed by the engineer Nascimento da Fonseca, this project contemplated a wide range of conservation, improvement and new construction works throughout the length of the supply system originating in Sete Fontes, from the collecting area to the aqueducts, tanks and distribution points inside the town, but it was never done due to constraints related to the management of water rights of the multiple consorts holders of these rights. Specifically in the area of Sete Fontes, this project involved the construction of several new basins of reception and load, connected by a new aqueduct of iron, which was only partially executed - iron pipes links in MI7, CP17 and terminal MI2, repair of some basins and placing iron gates at the entrances of the mines (Fig. 16).

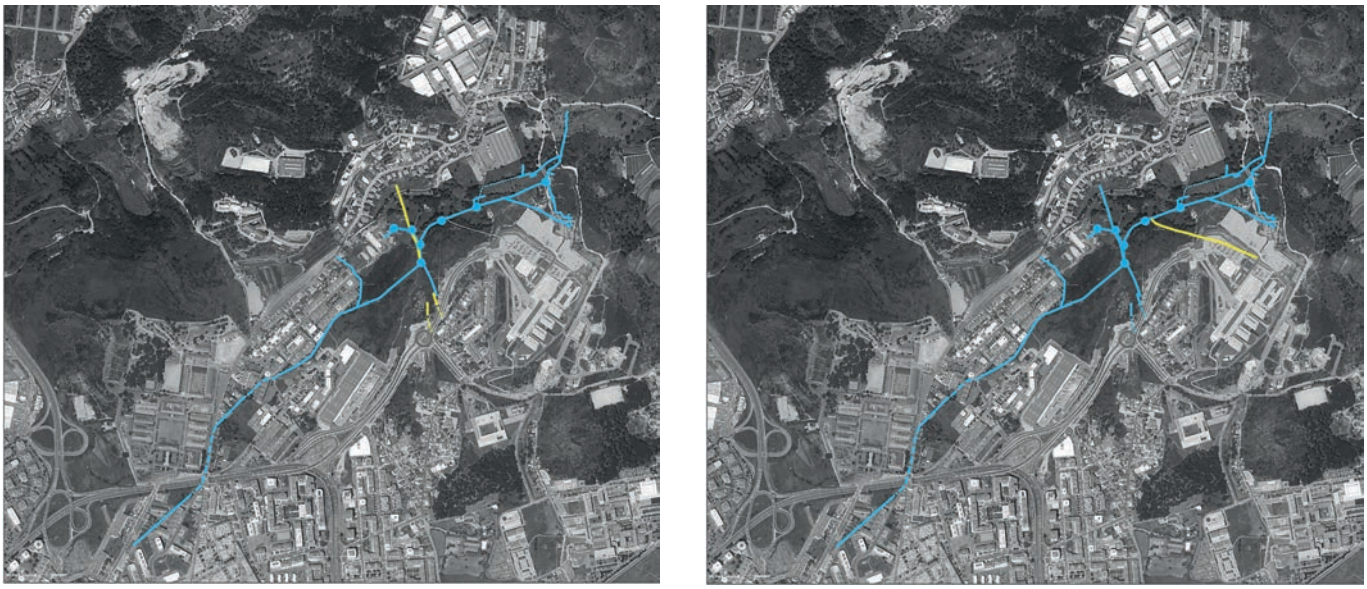

Figure 15. Cartography of Phases IX and X of the Sete Fontes's water collecting system. © UAUM

Phase XII (1970-2010) - Following the water collecting option in Cávado River, made in the early twentieth century, a new network of aqueducts, tanks and home delivery extensions was being built in the city of Braga, gradually disabling the distribution network of the Sete Fontes system, which was becoming obsolete and progressively abandoned. At the same time, the loss of importance of the hydraulic complex of Sete Fontes from the point of view of water supply to the city, along with the strong urban expansion that the city of Braga met, especially from the 70s of the last century, led to the progressive change of use of the Sete Fontes lands, which went from agricultural land to construction area.

The area has been changed with buildings for housing, industry and services, which deeply changing the surrounding, changing the hydrogeological balance which feeds the underground aquifers and today thus are threatening "to dry" the system. With the urbanization of the northern slope some sections of the main pipeline were even destroyed and in the southern slope some mines were affected and/or partially destroyed (Fig. 16).

Currently, through the classification of the system as a National Monument by Decree No. 16/2011 of May 25 and further definition of a Special Protection Area (Decree No. 576/2011 of June 7), urban expansion is conditioned, and a Detail Plan is being prepared, which aims to articulate the legitimate rights and interests of landowners with the necessary protection, conservation and enhancement of the monument.

CONCLUSIONS

The study of the water collecting system of Sete Fontes benefited from the data provided by archaeological surveys and stratigraphic-constructive analysis as well as the existence of numerous documents relating to it. All the structures above described, fully perform the solutions of classical hydraulic engineering for collecting and carrying water from underground aquifers.

Its length and layout reveal a deep knowledge of the hydrogeological characteristics of the site, since they were deployed to capture the existing water emergence in this granite with schist contact zone. Until the mid-eighteenth century, the collecting system was growing exclusively by exploring the north side water sources. From the mid-eighteenth century the catchment has also covered the southern side.

Regarding the construction techniques used, this set of structures reveals the total control of the know-how, patent in the constructive solidity of galleries and in the superior architectural of the main reception, decanting and connection basins, as evidenced by the vaulted domes and the cylindrical or prismatic ventilation chimneys.

The analysis of the stratigraphy of the construction allowed to establish the evolutionary sequence of the water collecting system of the Sete Fontes, confirming its origin in Roman times, its reinforcement in medieval times and its full consolidation in the course of the eighteenth century, revealing here the renovation

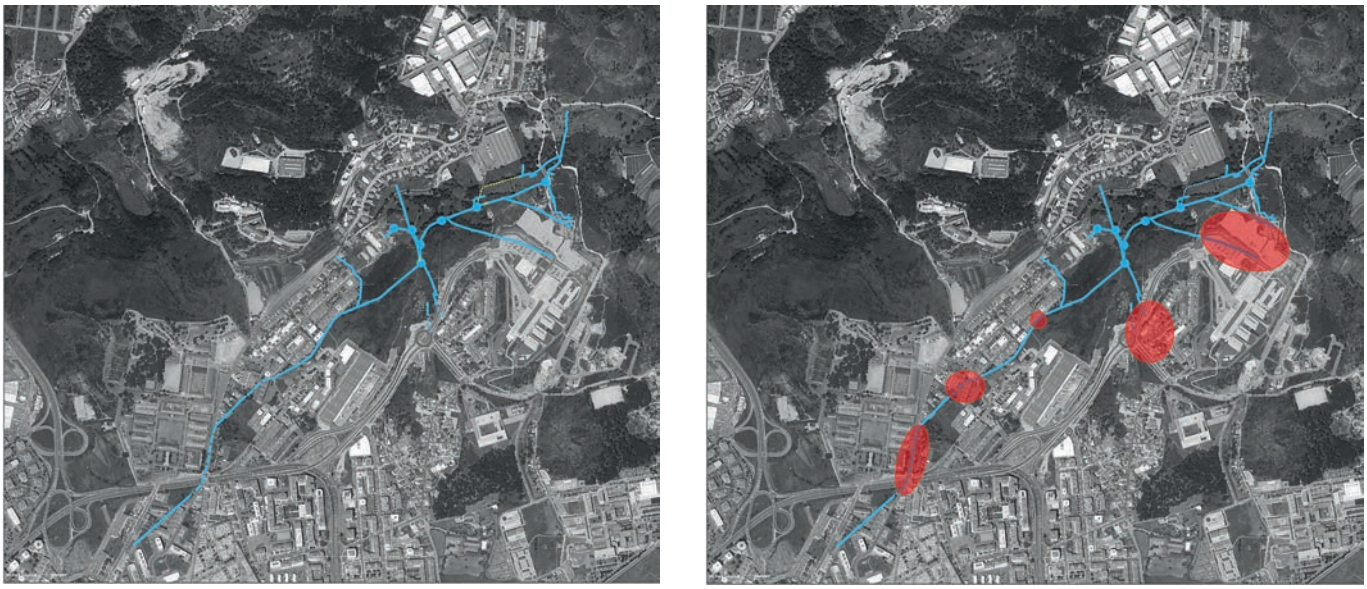

Figure 16. Cartography of Phases XI and XII of the Sete Fontes's water collecting system. © UAUM

project and appendage promoted by D. Rodrigo de Moura Teles and the Senate of the City Hall between 1704 and 1741.

Braga's water collecting and distribution system has evolved throughout the centuries, in a process that began with the remaining structures from the roman era, their posterior renewal and extension, a phenomenon recognizable in almost every ancient European city. In addition to the frequent roman origins, both the Late Middle Ages and the eighteenth century are also identifiable as two pre-industrialization periods where urban systems of water supply have underwent significant transformations, keeping up with the city's growth rate (Magnusson 2001; Mays, Koutsoyiannis and Angelakis 2007; Winiwarter, Haidvogl, Hohensinner, Hauer and Bürkner 2016).

The same phenomenon can be encountered in other ancient Portuguese cities, such as Porto, Coimbra, Lisboa, Setúbal, Elvas and Évora, whose urban expansion led to construction works of enlargement and improvement of their water supply system. In Porto and Coimbra, mainly from the seventeenth onwards, the priority seems to have been the extension of the water systems, through the addition of new subterranean galleries and aqueducts (Amorim and Pinto 2001; Teixeira 2011[6]; Almeida and Gonçalves 2005[7]). In the other four cities, besides the renovation of the preexisting systems, there were built long and monumental aerial aqueducts, like the Aqueduto dos Arcos, in Setúbal, built in the late fifteenth century (Rossa 2002; Trindade 2009[8]), also the ones in Elvas and Évora, built in 1530 and 1531-1537, respectively (Monteiro and Jorge 2007), and, of course, the most remarkable of this lot, the aqueduct of Águas Livres, in Lisbon, built between 1731-1748 (Amorim 2015[9]; Ferreira 1981; Pinto 1972; Serafim 2007).

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ACKNOWLEDGEMENTS

This work has the financial support of the Project Lab2PT - Landscapes, Heritage and Territory laboratory - AUR/04509 and FCT through national funds.

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