La storia di lunga durata del rapporto tra la civiltà e l'acqua evidenzia come tale risorsa rivesta un ruolo fondamentale non solo per gli usi che ne derivano, ma anche per i molteplici valori, tangibili e intangibili, che ad essa sono associati. Aver colto il legame tra tale risorsa naturale e il patrimonio culturale è il punto di forza del progetto europeo *Water shapes*, i cui obiettivi erano individuare categorie tematiche attraverso cui sistematizzare la conoscenza e valorizzare le "forme" culturali e materiali assunte dal bene acqua.
Questo volume si pone a momento conclusivo dei lavori del progetto, intendendo disseminare i risultati raggiunti e preparare il terreno per una organizzazione tematica dell'immenso materiale disponibile sull'argomento. Esperti di paesi europei ed extraeuropei presentano le "forme dell'acqua" nei rispettivi paesi, selezionate in un arco cronologico che va dall'antichità fino al 19° secolo, analizzandone le espressioni più caratteristiche e rappresentative, interrogandosi su questioni relative alla loro conservazione e confrontandosi sulle possibili strategie di valorizzazione.

The Water shapes *project's originality consists in its capacity to reveal the link between water as a natural resource and the cultural heritage: the history of the long-standing relation between civilization and water shows the fundamental role played by this natural resource not only because of its numerous uses, but also due to the manifold cultural values, both tangible and intangible, with which it is connected. The project's main aim was to identify thematic categories for the systematic organization of information and to promote the enhancement of the cultural and material "shapes" of the water heritage.*
This book marks the final stage of works related to the project with the aim of spreading knowledge of the results achieved and laying the ground for a systematic organization on a thematic basis of the immense material available on the subject. Experts from different parts of the world present the most representative and distinctive forms of water cultural heritage in their respective countries, over a period ranging from Antiquity to 19th century, raising relevant issues regarding their conservation and enhancement strategies.

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Water shapes *Strategie di valorizzazione del patrimonio culturale legato all'acqua*

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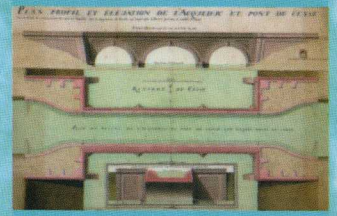

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Water shapes

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a cura di
Heleni Porfyriou, Laura Genovese

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Indice

The world reflected in the water. The eighteenth-century hydraulic system of the São Martinho de Tibães Monastery, Braga

Luís Fontes[1]
(Archaeology Unit of Minho University)

Introduction

The acquisition, distribution and use of water for the São Martinho de Tibães monastery performed, throughout the 18th century, a very important issue to the Benedictines, who wisely invested in the monastery hydraulic system's recovery, improvement and enlargement. Its complexity and quality was widely enhanced with the São Bento staircase, also known as *Rua das Fontes*.

This may, therefore, justified the special attention given by the recent global intervention project that took place at the monastery with the aim of conserving and recovering the site, which presents itself today as a key heritage asset for the appreciation of the Tibães monumental complex.

In addition to the fact the monastery is almost fully preserved, its study is greatly helped by the numerous documents referring to it, together with the data obtained by the archaeological excavation that took place at the site.

In the text that follows, and after a small synthesis framing the monument physical context, the landscape and its architectonic evolution, we present the Tibães monastery 18th century hydraulic system, describing its composition and the water uses.

More than acknowledging the existence of a rather well developed technical model within the monastery's hydraulic system, which is very similar to other European medieval and modern monasteries[2], we aim to underline the unique and irreplaceable value water has to human beings. This is what we hope to emphasise with the title of this presentation, reinforcing the idea that the technical complexities of the Tibães hydraulic system design solutions and the aesthetic expression of its forms is a reflection of the world, because they reveal the wise equilibrium achieved between Nature (the water cycle) and the Human Being (technical and art form).

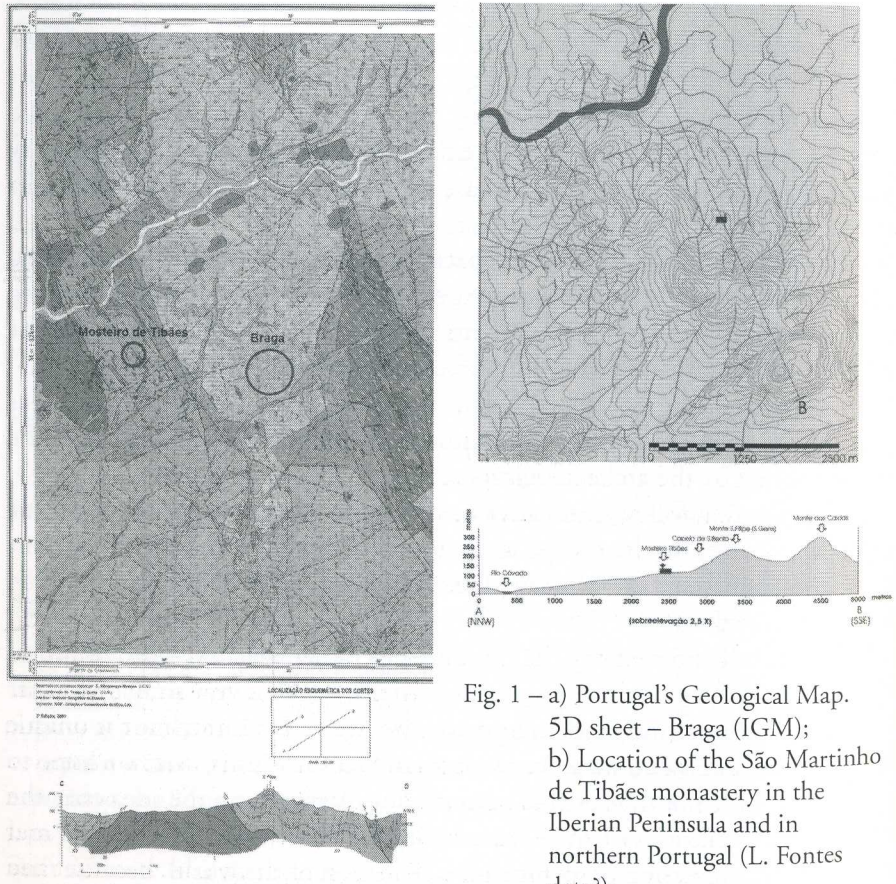

Fig. 1 – a) Portugal's Geological Map. 5D sheet – Braga (IGM);
b) Location of the São Martinho de Tibães monastery in the Iberian Peninsula and in northern Portugal (L. Fontes data?);
c) Relief, hydrograph and topographic profile of the Tibães monastery site (L. Fontes 2010).

The Site: Geology and Landscape

The Tibães monastery is located on a meta-sedimentary formation carried by tectonic and cropped by granite domes that sometimes arise, as the Monte das Caldas (304 meters) example. It is therefore a zone of contact of different rock formations, in which acted various structural accidents caused shears with dominant orientation NW/SE and intense fractures with an NW/SE and SW/NE orientation[3].

From a hydro geological point of view, the Tibães monastery is integrated within the Cávado river basin, which presents the following water draining ratings that are based on the hydrometric station recordings located near Padim da Graça[4]: global water flow = 6,1 m^3/s; underground water flow = 2,4 m^3/s; global specific outflow = 0,3 l/s per km^2; underground specific outflow = 1,5 l/s per km^2.

Taking into consideration the data regarding both the rainfall (with an annual average of 1515 mm) and the evapotranspiration (with an annual average of 619 mm), the calculation of the hydrological balance reveals an annual average evapotranspiration of 515 mm and a hydric surplus or superficial drainage of 989 mm, which means that there is an yearly average infiltration rate of around 1,3%. Due to the low or medium permeability of the rock formations', the water flow caption productivity is equally small, with average levels between 0,3 l/s and 3 l/s per km^2, which means that a very small amount of water is retained in the subsoil[5].

However, there is a higher permeability in the rock formations contact areas, as well in the sites registering higher fracturing, as for example the site where the monastery was settled. Confirming the existence of the hydrogeological conditions necessary to the existence of aquifers, there are the highest productivities, with captions up to 2 l/s[6]. Under these circumstances, it is very likely that the choice over the location of the São Martinho de Tibães monastery took into consideration the availability of water within the immediate surrounding region, a paramount factor to a long-term human occupation.

Nevertheless, the development of the necessary conditions for monastic life performed a more difficult challenge in this case than in other monasteries. Along with the necessary adaptation of the buildings to the slope, the collection of water and access to forest resources, an extra effort was required in order to create farmland, by framing the hillside in terraces or by embankment and drainage of thalwegs.

The São Martinho de Tibães monastery, located 6 km northwest from the city of Braga, has an altitude of around 110 metres and was established in a

Fig. 2 – Northern façade of The São Martinho de Tibães monastery (L. Fontes 2004).

lower slope of the São Filipe (São Gens) mountain, on a small headland flanked on the east and the west sides by two small watercourses coming from the high slope of the mountain.

It is dominated, on its northern side, by a wide landscape overseeing the Cávado river valley that extends itself towards the distant mountains of the Peneda, Amarela and Gerês, whose peaks above 1350 m high are covered in snow during the winter. On a closer range, one can see the medium reliefs of the Santa Isabel, Carvalho and São Mamede mountains.

This contrasting morphology is shaped by string reliefs, deep valleys, wide alveolus, hills and river valleys that are carved by several watercourses that feed the Cávado River. One is able to distinguish the intense agricultural occupation of the valleys' lower lands and the abrasion alveolus, as well as, the occupation of the forests near watercourses and slower slopes, with mountain peaks reserved for grazing.

Fertile land that has known since antiquity an intense but dispersed human occupation and is served by a dense network of road communications node polarized by the city of Braga.

Even today, the monastery marks the dividing line between the forest domain and the farming terrains, although this is an ancient heritage originated in the distinction between the *ager* and the *saltus*. The terrains above the monastery are mainly forest highlighting the 40 ha of the recovering climatic vegetation on the conserved monastery fence.

Below 100 metres, there are farming fields that are served up to the dwellings by a wide range of pathways and tracks. Enclosed by rubble walls, hedges and well-aligned trees, the small windrows terraced in the lower slopes and the wide flat fields run up to the watercourses dominate.

The monastery surrounding landscape still preserves the distinctive features of the countryside, punctuated by chromatic diversity that accompanies the seasonal variation of crops and vegetation.

The Monastery on Site: from the Medieval Foundation until the Current Recovery

In late 11th century, an initiative of Paio Guterres da Silva, the *vicarius regis* of Afonso VI, established a monastery in Tibães and since then it has been known as the São Martinho de Tibães monastery, of the Benedictine Order.

Practically nothing of the original building is known and the oldest archaeological remains, conserved on site, refer to a reconstruction of Romanesque features, believed to have taken place on the first half of the 12th century. Other than the Romanesque sculpted architectonic elements, there are remains of walls from the church foundation, attached houses and medieval remains of a necropolis. All these refer to the monastic establishment that served the local community between the first decades of the 12th century and the beginning of the 14th. The assessment of the archaeological data confirms the architectonic reconstruction model proposal, of clear Cluny affiliation, from where a church presenting a single rectangular nave is highlighted. This church has a semi-circular apse in the head-top and the cloister area extends itself towards the south, when it becomes adjacent to a garden[7].

The first documents which more deeply describe the monastery date back to the fifteen hundreds, a time when the monument witnessed several refurbishments and enlargement processes that kept the medieval church. Archaeology confirms the construction of a new block facing the west and the reconstruction of the cloister. On the northern side of the main chapel there are remains of the Nossa Senhora do Rosário chapel, established in 1555 under the initiative of the commendatory abbot friar Rosário da Cruz. To the same abbot is assigned the establishment of the São Bento chapel, located in the high hedge area, which, at the time, was already surrounded by a wall[8].

On the second half of the 16th century the monastic orders were reformed and the monastery was chosen as the headquarters of the Portuguese Benedictine Congregation, when the general-abbots promoted an ambitious project to reconstruct the entire monastery.

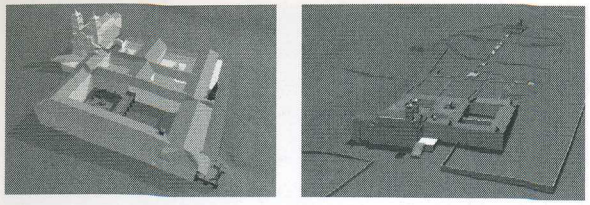

Fig. 3 – The São Martinho de Tibães monastery 3D Model, as it was in the 18th century (L. Fontes, C. Rodrigues data?).

The early reconstruction phase took place throughout the 17th century, and half way through that century both the dining hall and the cemetery cloisters were built with their respective surrounding wards. In 1661, the new and more monumental church was finished and in the mid-80s the bells were placed on the church towers and a new vestry was built. Moreover, the works in the main entrance and the cars gate were also finished and these became the monastery new entries. At the end of the sixteen hundreds, the construction work of the western block was finished, where they located the room receipt, barn and stables, workshops and cellars, dormitories, guest rooms, pharmacy, the library and the congregation chapter room[9].

A second reconstruction phase took place throughout the 18th century – the church front area was reshaped and the presbytery was enhanced. The cemetery cloister was refitted and the vestry was extended towards the east. In the southern part, a staircase was built and the side chapels were renovated. Furthermore, the kitchen and the chimneys also witnessed building works in the first four years of the seven hundreds. In 1731, a scenic and masterful walkway was opened and it separated the cellars halls from the São João garden. The fencing was subjected to key transformations started with the construction of a courtyard porch in the southwest area, followed with the framing of the São Bento chapel hillside in terraces and with the development of other pathways. The works of the monumental staircase, also known as *Rua das Fontes,* was finished between 1731 and 1734. Dating back to this century are also the lake, two watermills, the sawing engine and an olive oil mill located on the east side of the fence[10].

From a purely baroque aesthetic perspective, the Tibães monastery presents itself as a total art engineering work throughout the 18th century, mainly due to the admirable São Bento staircase, or as the monks used to call it – *Rua das Fontes* (Fountains Street) – that performs the centrepiece of the remarkable planning the fence was subjected to in this century. That's climbing a penitent but comforting way, pulsed by disappeared terracotta statues of Prudence, Justice, Fortitude, Temperance, Faith, Hope and Charity, not coincidentally

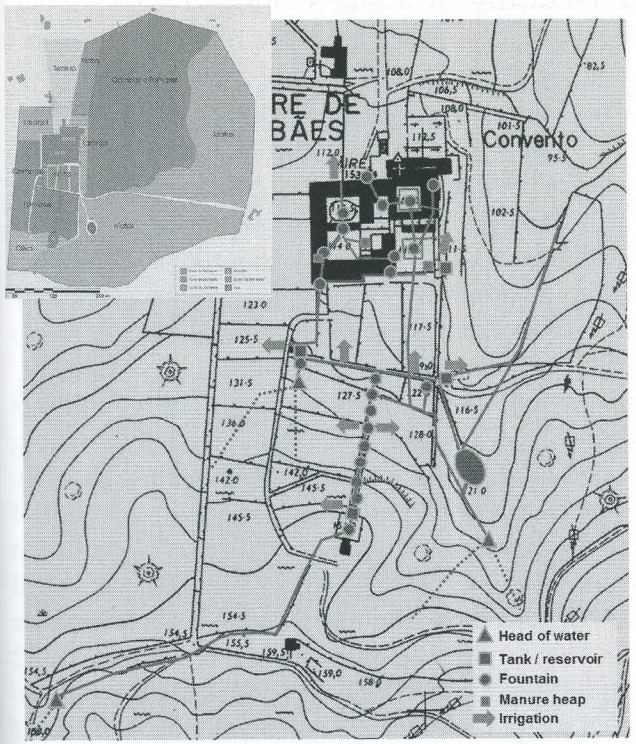

Fig. 4 – The São Martinho de Tibães monastery hydraulic system map.
In small, the 18th century Fence planning map (L. Fontes 2010).

aligned this sequence. The intimate character of the fence fruition is precisely originated from the subtle connection of the small gardening spaces with the surrounding farming terrains, together with the wide surrounding landscape[11].

With the extinction of the monastery orders enacted in 1833 and 1834, the monastery was abandoned and subsequently sold to private individuals. In 1894, a great fire destroyed the majority of the dining hall cloister, part of the east cemetery cloister and the novitiate area. Classified as a National Monument in 1910 and a Public Interest Monument since 1944, the monastery was again acquired by the Portuguese state in 1986 benefiting ever since of an integrated conservation, restoration and cultural promotion programme managed by the governmental authorities.

Providing an interpreted visitation, the monastery boosts a consolidated educational service, a study centre and a new hostel managed by a religious community, which has been internationally awarded[12] due to the quality of the intervention-integrated project. Last but not least, the Tibães monastery rebuilds itself as the headquarters of a cultural landscape.

The 18th Century Tibães Monastery Hydraulic System
The Composition

COLLECTION SYSTEM - The water intake system is done through composite structures, known as *mães d'água or minas* (heads of water or seepage tunnels), consisting of subterranean galleries excavated in the geologic substrate that run inside the hillsides slopes. These galleries have channels opened on the floor to capture aquifer waters and lead it towards a small tank, which receives and filters it. This structure is protected on the surface level by a small masonry construction covered by granitic slabs. It has a door that provides access to cleaning and checking procedures.

CONVEYANCE SYSTEM - The water conduction system is done through a complex network of either aerial or underground aqueducts comprising tubes/pipes and channels, from which the following types can be identified:

1. Lead tubes/pipes. With elements measuring 10m length and 0,08m of average diameter, these tubes/pipes run inside a masonry subterranean gallery covered by slabs, with junctions of granitic cubes that are pierced and sealed. The water circulated on medium pressure and was fed by a loading pit located at the lead pipe beginning. Between 1780 and 1782 lead pipes were constructed in order to serve the cloister fountains.
2. Common earthenware tubes/pipes. They comprise tubular shackles of circular section with joints of the male/female type that are sealed with lime thin mortar. They are always installed inside masonry underground galleries that are covered by slabs and frequently placed over tile beds and covered by mortar, in order to prevent eventual losses of water. They perform a common type of aqueduct that gravitationally leads the water towards the monastery for consumption. They are referred by *alcatruzes* in documentation.
3. Rock tubes/pipes. Comprising rock monolithic elements, with a "U" section and male/female joints, these elements are covered by rock slabs. Within the channels, with average levels of 0,15 m width by 0,10 m high, the water follows the gravitational course. They rarely reach their water limit capacity as they mainly serve the initial sections of the monastery supply system. They normally run underground or in surface sections over supporting walls or on top of arches.
4. Masonry gallery channels. These elements perform structured conducts with granitic masonry walls and slab beds that lead water gravitationally. They present either a square section or a "U" section with variable dimensions and rarely run in full capacity. On a surface level, they can

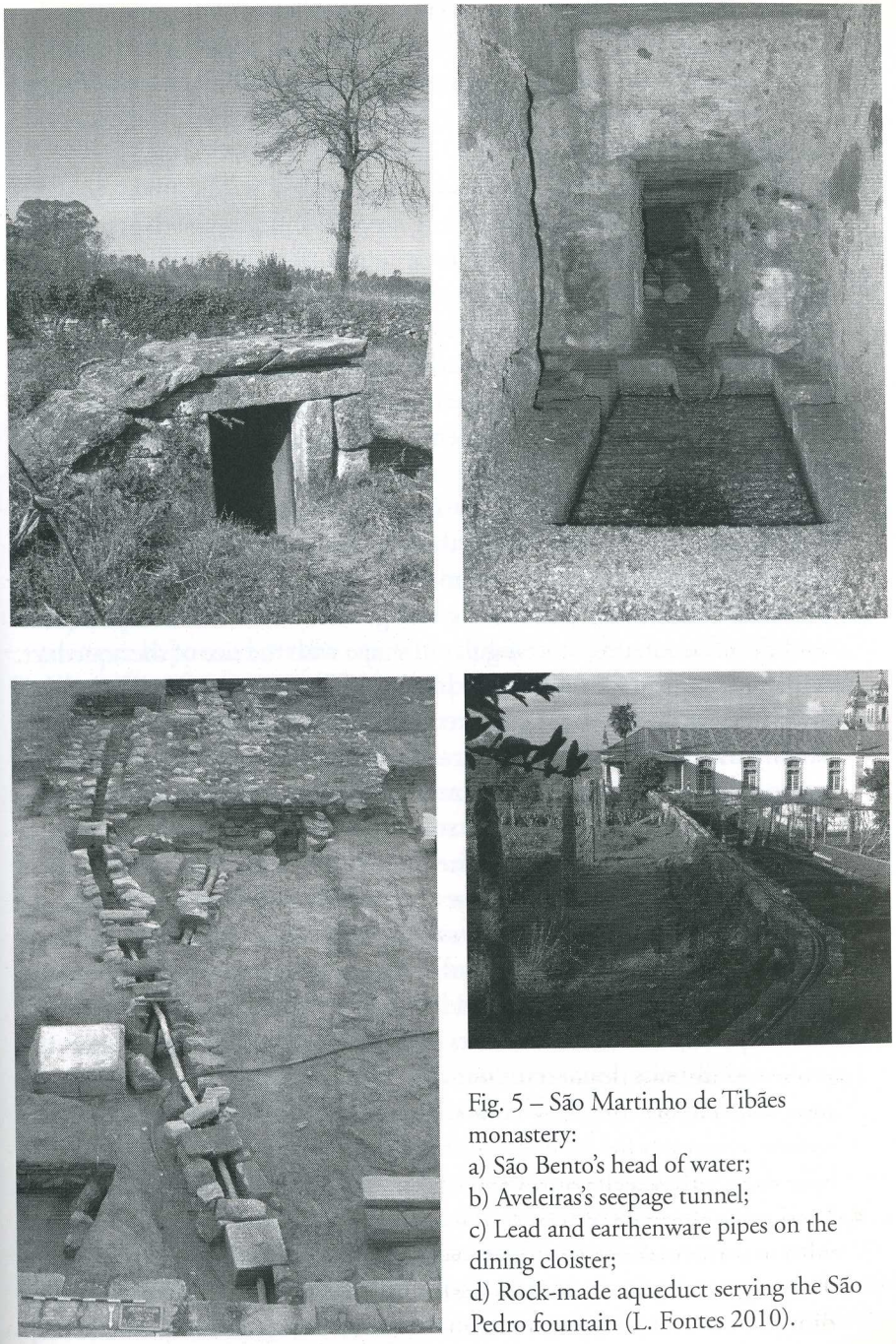

Fig. 5 – São Martinho de Tibães monastery:
a) São Bento's head of water;
b) Aveleiras's seepage tunnel;
c) Lead and earthenware pipes on the dining cloister;
d) Rock-made aqueduct serving the São Pedro fountain (L. Fontes 2010).

either be located on the terrain surface or be elevated on the top of arches and run in open sky, or they could be located underground covered by slabs. They are used in some external sections of the consumed water supply network, in the irrigation system and in mechanical devices (i.e. watermills and sawing engine).

5. Land trenches open channels (*levadas*). These are conducts inside trenches excavated on the terrain, of trapezoid section and average depth of 0.30 m. The water follows the gravitational course, in open sky, and serves the irrigation of farming fields or the maintenance of watermills.
   Throughout its course, the water transport and distribution network encompasses other intermediate outlets which serve a variety of functions, mainly related with the system maintenance, with the water quality control and with the water flow management. These structures are rarely featured in documentation.
6. Inspection chambers. Formed by small quadrangular granite masonry constructions, they present a door through which the aqueduct is accessed enabling its cleaning and preservation.
7. Filtration tanks. They present a small granite monolithic deposit that could either be square or rectangular in shape with the size of the aqueduct. This small open tank interrupts the channels and creates a lower level. This prompts the water to run lower than normal after the deposit filling, enabling the retention of heavy particles (sand and slimes) on the bottom.
8. Dipping places. With the same size as the aqueduct, these structures are formed by a small tank in granitic stonework either square or rectangular in shape or comprise a small granite monolithic sink. They receive water via a single entrance but present several outflows generally consisting of circular holes opened on the boxes sides. There are also alternative outputs with the size of one of the sides of the box, with the water flow being controlled, in this case, by a wood lock-gate.
9. Water depositories. These elements distribute themselves throughout the supply and distribution circuit with the main feature to allow the reserve water and manage the flow regulation. With quadrangular, rectangular or elliptical shapes, the latter being the example of the lake, they are mainly built in carefully developed granitic stonework. Many of these depositories served complimentary functions, such as embellishing water surfaces within leisure facilities and fishponds.
10. Loading pit. Of square section and built in granitic masonry, the pit is elevated above the surface in around 4m. It receives water on the top through a rock aqueduct and releases it on the base through the lead tubing that feeds the cloister fountains. The pit also ensures the necessary pressure needed for the water jets on the fountains.

DISTRIBUTION SYSTEM - The water is made available to its users in various outtakes points which present distinctive architectonic shapes. In Tibães the following are identified:

1. Nozzles. Single exit point with the main aim of supplying water, nozzles are formed by a small hole and/or tube almost always integrated in an architectonic element of small proportions that generally has the shape of a scowl or figurehead. The flow control, without pressure, used to happen directly on the exit point with the help of a plug or a metallic tap.
2. Fountains. Single or multiple exit points with the double aim of supplying and embellishing, fountains can be understood as a nozzle or integrated nozzles in an elaborated architectonic structure. Of backrest type, they normally had a niche or altarpiece and generally encompassed a reception basin located under the nozzle. Some fountains embodied an inside depository, like the fountain-lavers. The flow control, with or without pressure happened on the exit with a plug or with a metallic tap.
3. *Chafarizes* (fountains). With multiple exit points, this type of fountains comprised a single sculpture piece more or less elaborated, several nozzles and spirts, bowls or sinks basins and a tank. They have a primarily embellishing function. The flow control, under pressure, was done on the supplying conduct, inside a box placed on the exterior side near the base.
4. Receptacles. Delivering points with the water coming either from a nozzle or directly from the aqueduct, they were formed by a square or rectangular granite monolith with water hollow. They either served as deposits for several uses, like lavers for washing hands, kitchen sinks, laundry basins or watering troughs animals. The latter could either have a continuous flow pouring the remaining water either via a notch or a torn hole on the upper level. The flow control, with or without pressure happened on the nozzle with the help of a plug or a metallic tap.

DRAINING SYSTEM - The drainage of leftover and dark waters, together with rainwaters, performs an equally important element of the complex hydraulic system in Tibães, from which several building constructions are identified:

1. Common earthenware tubes/pipes. Similar to the pipes meant to supply water, these tubes/pipes run on subterranean gallery or directly on the

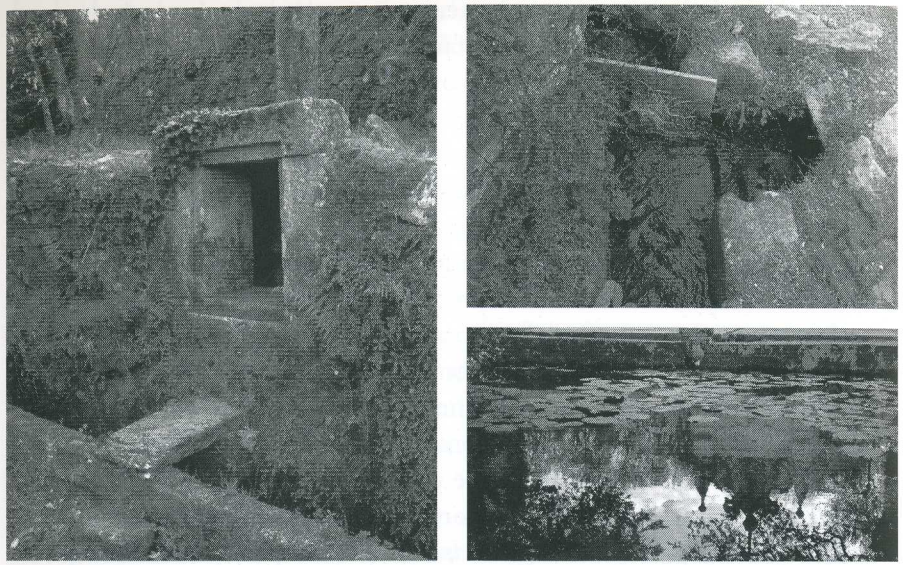

Fig. 6 – São Martinho de Tibães monastery: a) Aqueduct inspection chamber; b) Water dipping place, with wood lock; São Bento fountain tank perspective (L. Fontes 2010).

terrain. They evacuated the remaining waters from the fountains, as well as, the rainwaters from the cloister area.

2. Rock tubes/pipes. Comprising granite monolith elements of semi-circular section and with male/female joints, they present excavated channels on the upper level and are covered by slabs. They were buried, directly settled on the terrain and evacuated rainwaters from the dining hall cloister.
3. Masonry gallery channels. Similar to those that supplied water, they present several variations dependent on used building materials. Some have been identified as being built with brick masonry. They evacuated rainwaters from the dining hall cloister, leftover waters from the respective dispensers and unclean waters from the stables.
4. Land trenches open channels. Similar to the water supplying *levadas*, they evacuated black waters from the kitchen and manure heaps deposits.

Uses and Architectonic Shapes

The water channelled on the distribution network, with or without pressure, served several different functions. It was consumed by the monks, servants

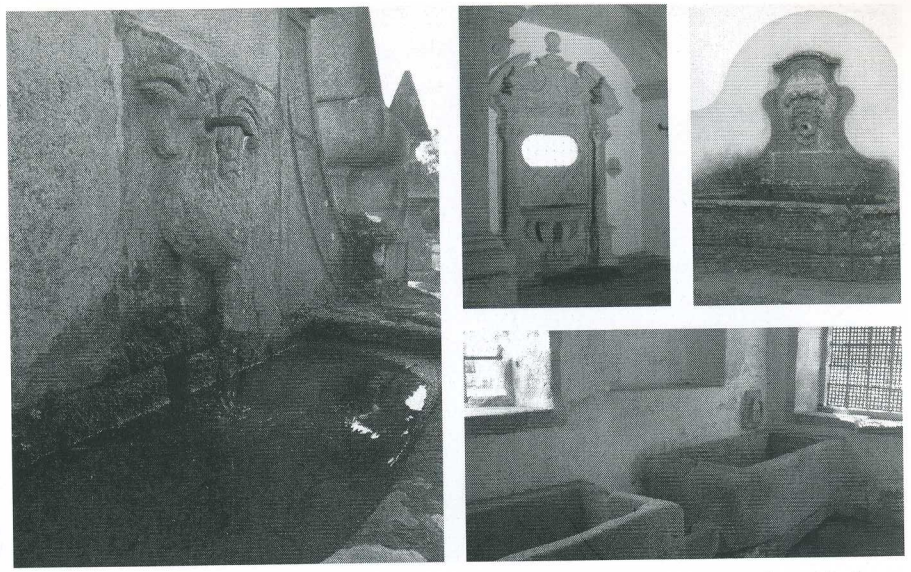

Fig. 7 – São Martinho de Tibães monastery: a) Rooster nozzle; b) Vestry atrium fountain-laver; c) Nozzle and water trough in the Car Gate; d) Nozzle and kitchen sink (L. Fontes 2010).

and animals alike in location points throughout the monastery: to prepare food in the kitchen; for hygiene and health practices by the monastic community in dormitories, latrines and at the pharmacy; for leisure activities at the lake and in the fountains; for the irrigation of the farming fields; and in watermills and sawing devices.

Within the 18th century renovation context, the water outtakes points were given special attention and performed a paramount element of the wide decoration programme that was very much inspired by baroque art brought to Tibães by the Benedictines.

Sculptures and architectonic decoration were present in almost all the nozzles, fountains and water dispensers in the monastery, from the tank located on the cars' entrance, whose primarily function was to serve as a watering trough for animals, to the cloister fountains, however the monastic fence, in the popular *Rua das Fontes*, performed a perfect aesthetic and leisure nature staging.

The nozzles, fountains and sinks provided water to both human and animal consumption. The water could be drunk directly from the source or collected in containers and transported to another place. This is the case of the Cordeiro or the São Pedro fountain, the latter also known as the Galo (Rooster) fountain due to the fact the water was drained from a sculpted rooster embossed in the backrest.

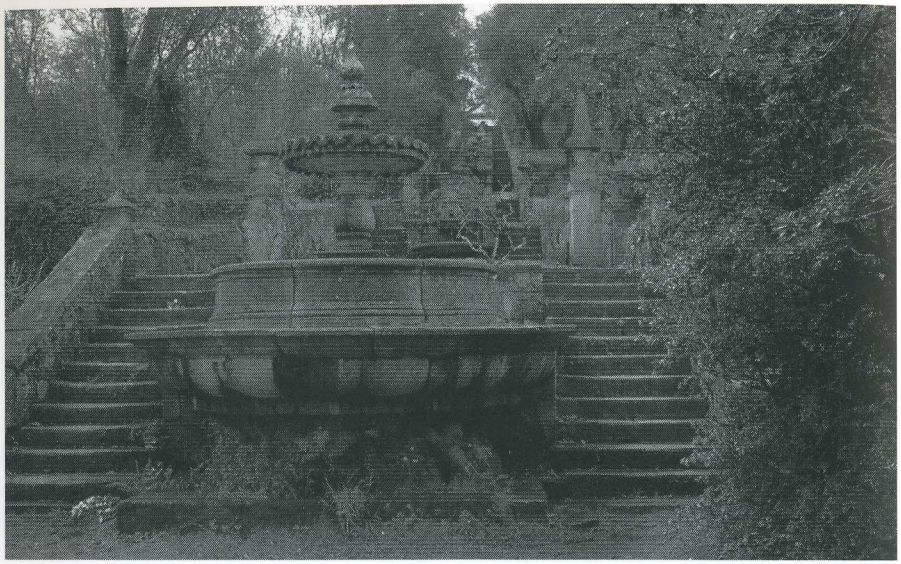

Fig. 8 – São Martinho de Tibães monastery: São Bento staircase or *Rua das Fontes* (L. Fontes 2005).

Water used for cooking was made available in the kitchen through nozzles. It could have been poured in sinks or have been collected in containers.

The water required for hygiene and health practices was made available through nozzles and collected in containers and transported to another place. This would happen in the fountains, some of smaller dimensions as the Botica fountain and others with bigger sizes and apparatus that served as lavers to wash hands and the face. Examples of the latter are the vanished dining hall cloister laver and the conserved laver located at the vestry atrium.

The water in fountains and *chafarizes*, the subject of a more careful architectonic embellishment, could directly be consumed but it was mainly destined to leisure activities. The fountains association with tanks provided bodies of water, as for example the São Bento fountain. The *chafarizes* presented congruous designs shaped by the sprits and by the water singing sounds falling on the bowls and tanks, as for example on the São João garden. The lake, meant to mainly store water destined for devices, was the object of a thoughtful ornamental fix, equally serving recreational and leisure practices.

In Tibães, no water was lost. The draining system of clean or black waters would lead it towards exit points that fed the irrigation system that was formed by exterior channels/*levadas* that would fed the land.

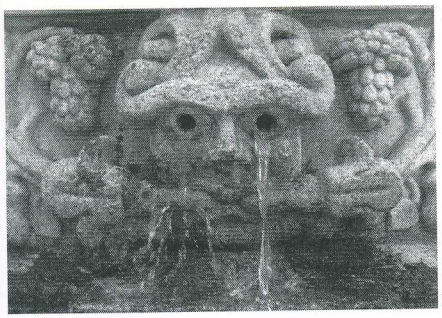

Fig. 9 – São Martinho de Tibães monastery: Sculpted nozzle detail in *Rua das Fontes* (L. Fontes 2010).

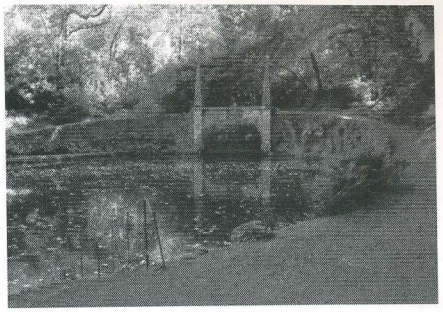

Fig. 10 – São Martinho de Tibães monastery: Lake perspective (L. Fontes 2005).

The integral exploitation of unclean, leftover and rainwaters were equally important and integrated the exterior site irrigation system. If today's black water mix within the irrigation system practice may be seem somehow reprehensible, we should acknowledge that it is still a common practice taking place in rural areas. Black waters accelerate the organic matter decomposition and produce manure meant for fields fertilization.

Lastly, part of the water distributed by the Tibães hydraulic system was used as the driving force of watermills, such as the Ouriçosa case, or the gone sawing device.

ENDNOTES

[1] Tradução de Joana Baptista.
[2] MAGNUSSON 2000; AA.VV. 1996.
[3] FERREIRA et al. 2000, pp. 8-12 e 40.
[4] *Ivi*, p. 44.
[5] *Ivi*, pp. 44-45.
[6] *Ivi*, p. 46.
[7] Fontes 2005, pp. 116-126.
[8] *Ivi*, pp. 127-134.
[9] *Ivi*, pp. 136-142.
[10] *Ivi*, pp. 142-148.
[11] *Ivi*, pp. 148-155.
[12] *Carlo Scarpa International Prize for the Garden. 1998. Cerca do Mosteiro de Tibães*, in Luciani 1998.

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