DE AQUAEDUCTU ATQUE AQUA URBIUM LYCIAE PAMPHYLIAE PISIDIAE

The Legacy of Sextus Julius Frontinus

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Roman Water Supply Systems
New Approach

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Abstract

The main aim of this paper is to synthesize the author's assessments on the Romans' high technical knowledge and skills regarding water supply systems and hydraulic engineering. It will also highlight some key-misunderstandings (still present today in Roman engineering literature) in this particular domain, which are due to the lack of, on one hand, key-archaeological elements and, on the other hand, an appropriate engineering approach to the subject.

One example of lack of archaeological elements concerns water conduits. The supply of drinking water to Roman towns consisted of underground conduits, many of them designed to be operated under pressure using pipes of various materials. Metallic pipes were systematically looted after the fall of the Roman Empire; hence the current lack of information on most of these water supply systems.

An example of the lack of engineering approach is to be found in the current concepts of dams and water reservoirs. The universal sources of water supply for human consumption were springs with an abundant and steady flow of good-quality water. Dams were not suitable for the purpose; furthermore, recent research allows us to conclude that they were not used for it.

In addition, most aqueducts had decantation basins. Sometimes they were very numerous and small, and other times remarkably large. However, contrary to common belief, these basins did not store water to regulate water flow, that is, they were not water reservoirs. The same flow that got into them, sometimes very large, went out once decanted. Flow rates that were not consumed were drained to clean the sewage system.

Finally, similar problems can also be found in the topographical domain. The topographical work associated to Roman water supply systems was complex but very accurate, thanks to the instruments used for this purpose. It is important to note in this regard that the current theories on topographical instruments like the *chorobates* or the *dioptra* need to be reconsidered; the proposals made to date are practically useless in the context of these systems. More specifically, the interpretation of the table-shaped *chorobates* made by Perrault in the 17th century is not tenable, if we make a correct translation of Vitruvius writings.

The following sections will get deeper into the aforementioned issues, looking into the key-elements of water supply in Roman times: The importance of water supply in Roman civilization, water uses and quality, dams and irrigation methods for water conveyance (non-pressurized and pressurized) decantation and topography.

Meeting Water Demand

Human water supply was a political and health issue in the Roman World. As it was essential for the maintenance of the Roman way of life, human water supply was guaranteed even before the accomplishment of other public works that were also necessary for the city's development. Not surprisingly, Pliny wrote that '*water creates the city*'.[1] Normally, before building a city, drinking water supply had to be guaranteed. The exact location of the city was often decided by the technical possibility of transporting water into it.

Vitruvius clearly points to the need to find water in sufficient quantity and quality to ease the city's development and to the way of checking its quality, to convey it and to distribute it.[2] Water supply was a priority for Roman rulers. Thus, such an essential service was carefully legislated, administered and provided. Rulers achieved respect and admiration of the Roman population by building public works, including those intended for water supply, which were the most appreciated. The welfare effect that aqueducts had on people was the best advertising that rulers and prominent people could do at that time, and certainly they did not miss the chance to perpetuate their names as benefactors on inscriptions placed with this purpose (*fig. 1*).

The works of water supply to be undertaken between the original source and the distribution point or basin were often technically complicated and expensive. However, people did not fully

Fig. 1. Ephesus, Pollio Aqueduct - bridge (Turkey). An example of a spectacular construction preferred to an easier engineer solution. An alternative to this whole structure would have been a cheaper pipeline system with siphon. But precisely, the passage of the road from Ephesus to Magnesia advertised this work to travelers, with the inscription: 'C. Sextilius Pollio, Offilia Bassa, C. Offilius Proculus his wife, and his sons, pooled their resources to build this bridge.' *Pipes under the road would not have glorified anyone (photo author).*

appreciate this achievement because these engineering works were seldom visible to the public. Perhaps for this reason, on many occasions unnecessary and ostentatious constructions were preferred to the said non-visible engineering works, due to their unquestionable advertising effect. In effect, there are many cases in which large arcades could have been replaced by pipe siphons, which were equally effective and cheaper to build.

Supply of Drinking Water

It is necessary to insist on the crucial issue of drinking water quality, which was the primary target sought by Romans when thinking of water supply. In the texts of *Frontinus* we can see how important the quality and the taste of the water were in Rome, representing an issue that came to be considered a matter of state. Similarly, we find in these texts many of the techniques used to achieve the best qualities at the catchment areas and to allocate water of less quality for other uses.

Romans sought the most suitable drinking water, meaning thereby the water that originally was the clearest, the coldest, collected at higher altitudes, and better-tasting. Once this water was collected, they insisted on maintaining its qualities at all costs, covering the channels and avoiding sunlight, preventing solids entrainment by lowering the water speed, and eliminating contact with erodible material.

Various specific thesis has confirmed the imperial aspirations described by *Frontinus*. It is important to note in this regard that some of these thesis, particularly the technical - constructive study concluding that dams in Mérida (Spain) are not of Roman origin, lead to a wider problem by questioning the use of water kept in reservoirs, stagnant or of poor quality for human consumption in the Roman world.[3]

Other classical texts support the said concerns of Roman technicians to preserve the population's health. Vitruvius: '*For all this, we should take the utmost care and skill in finding and selecting good springs to protect the health of humans*.' [4] Palladius: '*Water healthiness is recognized as follows: first, it must not come either from pools or ponds ...*'.[5]

Therefore, we have to consider the conclusion that drinking water in the Roman world was sought mainly in quality springs, in galleries or catchments made for the purpose, or in cold and quality mountain waters, caught from small lakes or mountain streams. Wells would only cover water supplies where the previous mentioned catchments were not available. Reservoirs holding stagnant water did not have sufficient quality for the intended healthy function, and if they would meet the requirements, their quality was neither permanent nor verifiable by Roman technology, which in these cases was based on empirical methods. Given the possibility of catching water out of springs and having the appropriate technique to bring water from far away, sometimes covering remarkable distances, the fact of relying on reservoir water (however good it might be) for drinking uses involved a high degree of risk and was actually far from the Roman good sense and pragmatism.

Dams and Irrigation

The role of dams in the Roman world is not sufficiently clear today. Since recent research seems to show that water storage was not intended for human consumption, these structures could only be used for agriculture, and for the irrigation of large areas. Large agricultural subdivisions in the Roman world occupied flat and perfectly irrigable lands, many of which still fulfill that mission.

Irrigation meant a dramatic increase in agricultural wealth and the ability to produce high value alimentary products in large quantities (the horticultural varieties of that time). The market generated by this new production system generated enormous wealth areas where previously only a reduced indigenous population survived. In other cases, large Roman dams are known in an area, but the irrigation field or traces of the plots are unknown.

In Spain, authentic Roman dams are rare (much rarer than those assumed as such).[6] This is also true with regards to other structures of this period. We understand as clearly Roman those constructions with a masonry work that is aligned with the construction procedures of the time.

Regarding the case of the dam of Almonacid de la Cuba (Zaragoza) with a storage capacity of six million cubic meters and a closing wall thirty feet high, it is estimated that it would irrigate more than seven thousand acres.[7] It was probably one of the highest dams in the Roman world, although most of its masonry work cannot be considered Roman, being the result of subsequent additions.

Among the truly Roman dams known in Spain, we can only mention, due to the accuracy of their dating, the one of Almonacid de la Cuba (Zaragoza) and the one of Muel (Zaragoza). The Roman origin of the dams of Proserpina and Cornalvo in Mérida has been questioned recently,[8] with well-founded criteria. Many other dams located in Spain and today considered Roman, but in fact they do not meet the required structural features and there is not sufficient data available to consider them as such. In other cases, reforms or subsequent additions hide or complicate the identification of their Roman parts. That is the case of the dam located in the Roman city of Andelos (Navarra), now promoted as a reservoir that supplied drinking water to the Roman city[9] in spite of not corresponding at all with the characteristics of a Roman masonry work.

It is necessary to clearly state that the number of dams currently considered as Roman, mainly in Spain, is enormous. But in fact, there is hardly any proof that could confirm this. In addition none of them matches Roman building models. The authors who stubbornly advocate the idea of Roman dams being used for drinking water supply[10] actually feed in the aforementioned ideas: '*The most updated studies we know on the subject indicate the existence of 73 dams or catchment areas of Roman origin in Spanish territory*'.[11] In the light of above, it has to be noted that that many other ancient dams in the Mediterranean area which are considered of roman origin will require a detailed study in the near future to clearly determine their allocation (or not) to the group of Roman structures.

Civil engineers know the trade-off between the water speed in the channels and the work's durability, being aware that a difficult balance has to be maintained. The water speed in the channels is directly dependent on the channel's slope. The steeper the slope, the faster water flows. The roughness of the wetted surface also determines the speed, but to a much lesser extent. In the modern world, there are also channels and ditches that are easily ruined, due to design defects associated to inadequate slope, or other factors that cause turbulent water flow. Repairs, which are always expensive, are required to cover channels with more resistant and durable materials.

One can be surprised when reading the Natural History by Pliny who indicates that: '*channels must be as solid as possible, and their slope should not be less than a quarter inch per hundred feet of length*.'[12] This extremely small slope equals a 20 cm drop per km, which results in 0.02%. Despite this, the slope is the most common in known Roman channels. In fact, a channel as that of Nîmes (France), which is 52 km long, scarcely exceeds that percentage and keeps lower slopes during much of its course.

Despite what has been believed to date, the formation of calcareous concretion in aqueducts did not necessarily mean its write-off. The constant maintenance of the aqueduct was a reality, in times when Roman administration was in effect. In relation to some of the aqueducts in Rome, it is known that they were subjected to the removal of calcareous concretions in order to bring their section to its original shape. The same thing did not happen to the aqueduct of Nîmes (France) or to the one in Cologne (Germany). Probably due to times of crisis during the late Empire, when a proper state administration no longer existed, or competent technicians couldn't be found, the lack of maintenance works meant that no action was undertaken for the removal of calcareous concretion or any other measures which would have prevented the death of the aqueduct.

Manholes (shafts) were uniformly distributed along the conduit to ease its maintenance. Besides, in the tunnels excavated into the rock, these shafts

Fig. 2. Final part of the excavation in rocky ground and beginning of the vaulted channel of the tunnel crossing lose ground. Gallery of the Gier aqueduct, at the so called Cave du Curé, in Chagnon (France) (photo author).

also served to facilitate the simultaneous excavation on several fronts and the withdrawal of materials. They also served to ventilate the conduit, to facilitate setting out works through the introduction of the main alignments (by means of plumb bobs and ropes) and finally to mark the aqueduct's alignment on the surface, thus controlling the aqueduct's right of way.

The geometric control that the Roman engineer had over these underground tunnels was almost total (*fig. 2*). Even today, the setting out of the narrow tunnels of several kilometers in length would be difficult. But, in the Roman world, we know of the existence of several of them having an impressive length. The aqueduct from Albar-racín to Cella (Teruel, Spain), has a five kilome-ter-long tunnel. It has shafts of up to 60 m deep,[13] over its whole length. This length is comparable to the tunnel that served to drain the lake Fucino (Italy), which reaches 5.64 km and was made in the time of Claudius, though this one was built with shafts as deep as 122 m.[14] There are longer tunnel lengths in the Empire. We know, for exam-ple, one of the aqueducts of Aix-en-Provence (France) which is about seven kilometers long and has shafts up to 80 m deep.[15] The aqueduct of Drover-Bergh-Tunnel (Germany) has a channel of only 1.66 km, but it is suspected that the Bolo-gna aqueduct (Italy) has an uninterrupted tunnel of about 20 km.[16] Finally, Matthias Döring, University of Darmstadt, discovered a few years ago that the aqueduct of Gadara (Jordan) had a 106 km tunnel. Almost the entire aqueduct is an unin-terrupted tunnel.

Pressurized Water

When flow rates were low, or the situation afforded the implementation of pressurized water, pipes were installed. These could be mainly composed of ceramic, lead or stone. Sometimes, the whole conduit was composed of pressurized pipes. At other times, this solution was implemented on a single section.

Siphons were installed using a single pipeline or a series of them. Romans had specific masonry to ensure that pipes were properly fastened to the ground, if this was required to withstand the pressure that was put on them (water height). These technical elements, contrary to what is commonly believed, were very common in the supply of cities, and in some cases of impressive sizes (*fig. 3*).

Roman lead pipes have been preserved to this day only in a few cases. Those that remained on the surface were looted after the fall of the Roman Empire, due to the value of the metal. Of the thousands of tons of lead pipe belonging to the four giant siphons of the Gier aqueduct supplying *Lugdunum* (now Lyon, France) no trace has been found.

Fig. 3. Image of the large siphon of Patara (Turkey), made of stone pipe (photo author).

Just the name of the hillside where one of the siphons was located, that of Genilac, now called 'La Plombière' reminds us of this ancient construction.

Decantation

Romans had no chance of purifying water from the bacteriological or chemical point of view, and by no means could they risk to supply polluted water.

Therefore, special chambers where built to force a sharp water speed reduction, by means of suddenly widening the channel's section. Thus, suspended particles settled at the bottom, decanting. At a constant flow rate, when a channel arrives at a large tank a remarkable section increase takes place, which reduces speed in the same proportion. In addition, if water is forced to flow at a very slow speed for a long time, the removal of suspended solids will be total. Water would then become crystal clear, no matter how muddy it was when reaching the tank. Sometimes the deposit itself was a great feat of engineering, due to its immense size. The case of Carthage (Tunisia) was famous, where the immense decanter consisted of fifteen elongated parallel chambers, each 7.4 x 102 m long - true giant with a volume of 60,000 m^3. In these cases, while some chambers were cleaned of sludge at the bottom, others remained full, developing their decanting function (*fig. 4*).

Contrary to the popular belief, it seems now demonstrated that in the Roman world water was not stored. These remarkably large deposits did not have a water storage function (for water flow regulation); their mission was simply to decant and to purify water from its suspended solids. Each litter of water arriving into these decanters, always at the top of the chambers, went out at the other end, again from the top. Sometimes it took several days to complete the course, at a speed tending to zero. This alone is the secret of decanting. Those who consider these basins as reservoirs do not take into account that the flow rate provided by the aqueduct (sometimes by many of them) was very high and very consistent throughout the year. These basins have only rarely lower outlets for draining and cleaning purposes, but not for the use of stored water, which would also be full of decanted mud. This type of premise is due to the traditional lack of participation of competent engineers in this domain. This is also the reason

Fig. 4. Interior view of one of the settling chambers in Carthage (Tunisia) (photo J.C. Litaudon).

why sometimes the capacity of Roman hydraulic technique has been assessed at a level below its real achievements.

Therefore, the regulation of flow rates hardly existed in most drinking water supply systems to Roman towns. Water caught from springs reached the decanter, there it was cleaned, then it left the decanter to be distributed through a pipeline and finally it arrived at public fountains and final consumption points. A volume almost equivalent to the one that entered the aqueduct reached the sewerage system at the end. Water needed to have an outlet in non-peak hours, when the taps of the houses were closed or when public baths closed. Although the flow was constant to the pools of the baths, technicians could decrease the flow during non-peak hours, closing valves.

At night, the spillways of the distribution network operated at maximum. At some point, when the channel's water level exceeded certain limits due to a low consumption rate, the channel sent water directly to the sewers. However, the large number of fountains arranged in town also fulfilled that role. Moreover, these fountains also undertook an additional mission that was no less important than to secure consumption, mentioned by Frontinus in his writings: to thoroughly clean the sewer systems.

But, did Romans actually store water in some cases? We should pay attention to these words of Pliny: '*Physicians investigate what types of water are the most suitable for consumption. They rightly condemn those that are stagnant and immobile, whereas they consider the best ones those that flow, that are purified and improve through their course and through agitation. Therefore I am astonished that some people give their enthusiastic approval to water that comes from cisterns. Physicians recognize that water from cisterns is inadequate for the stomach and throat for its hardness, and that it contains more slime and more disgusting insects than other water types*'.[17]

Thus, and according to this new point of view concerning the Roman's management of water supply flow rates, we will not find many cases of deposits that could be considered reservoirs (regulating basins). Most of what has been considered so far as reservoirs are actually mere settling or distribution basins, including both the large and the small ones. The cisterns of Constantinople represent real regulating basins and water stores. However, they cannot be considered a work of Roman engineering, for they belonged to periods of the Late Antiquity or the Early Middle Ages. Amongst the many cisterns that were built in the city (under Justinian in the 6th century), that of Yerebatan or House of Medusa excels. It had a capacity of 80,000 m^3. The need for these large-sized cisterns was a result of the successive sieges that the city suffered during unstable periods, the deterioration of its legacy of imperial aqueducts, largely due to the technological decline that prevented the provision of new aqueducts or the repair of those that were destroyed. The Yerebatan cistern itself was built with the rubble of the formidable pagan monuments, which were condemned by Christianity, but built with an almost dead scientific and technical level, as dead as the rest of the science and the lifestyle of the *Roma Aeterna*. The first great epidemic of the Black Death known in Constantinople, is coeval with the construction and use of these deposits. Thus, this is to give the starting signal for the technical-scientific medieval misery at the time when the Roman sanitary engineering died, not being surpassed until the present day. Indeed, the storage of the already scarce water volumes left the huge sewer system of Constantinople in a bad sanitation condition, becoming a giant rat's nest, and a great breeding ground for the spread of the bacteria *yersinia pestis*. Rats and their fleas infected humans with the dreadful disease that came to decimate Europe's population for centuries.

The Topography

We have deduced the collection and channelling techniques employed by the Romans, their structural features, materials used and their technical and artistic excellence from a detailed observation and analysis of Roman water supply works that have survived to this day. These aqueducts worked for over three or four centuries with a high degree of efficiency, preserving the population's health and thus allowing the survival of a very advanced civilization in all fields of science. Actually it was science itself that enabled the existence of these channels.

The levelling works made for these channels, often several tens of kilometres in length, were considerably difficult in those times. Moreover, they would be equally difficult considering the optical topographical instruments of modern times. The results obtained by the Romans in this domain are only possible through rigorous scientific levelling. Advanced topographical techniques must be known, as well as the shape of the planet Earth, its dimensions, and the influence that these have on the levelling of great lengths.[18] In addition to this knowledge, precision instruments are needed to allow the collection of main altimetry data for the project and construction of the aqueduct, as well as to carry the necessary setting out works.[19] The influence of the earth's round shape in water surface level was known in Roman times, at least from Archimedes' postulate.[20] It was already known that long measurements in levelling tasks caused the greatest errors.

There were various instruments used for levelling water. The *dioptra* is known to be used for levelling purposes but, as Vitruvius himself announced, for precise levelling a *chorobates* was used. Both instruments have been the object of analyses and interpretations over the centuries, as only a few classical texts described them vaguely. After ascertaining the little success of reconstructions proposed to this day, with the production of totally ineffective devices, we have rebuilt both devices following the descriptions of the available classical texts. Thus, we found that both the *dioptra*[21] (a true theodolite of antiquity) and the *chorobates*[22] had an admirable efficiency and precision, well up to the great challenges of Roman public works (*fig. 5*).

The key error introduced by Claude Perrault in the 17th century,[23] was interpreting the word 'ancones' as legs when the correct translation is 'brackets'. The other authors who drew the *chorobates* in the translations of Vitruvius of the 16th century, described the *chorobates* correctly, with brackets at the ends (*fig. 6*).

The Roman and the modern levelling instruments (the latter equipped with optical elements), have been subjected to different tests. The result has been that both showed a comparable accuracy, both of them being suitable to accomplish the most difficult levelling tasks, as the ones that have been mentioned further above.

Fig. 5. Reconstructed dioptra and chorobates, which have been patented by the author. It has been frequently shown during the successive annual celebrations of the Tarraco Viva event in Tarragona, as well as in other similar events in Segovia, etc. (photo author).

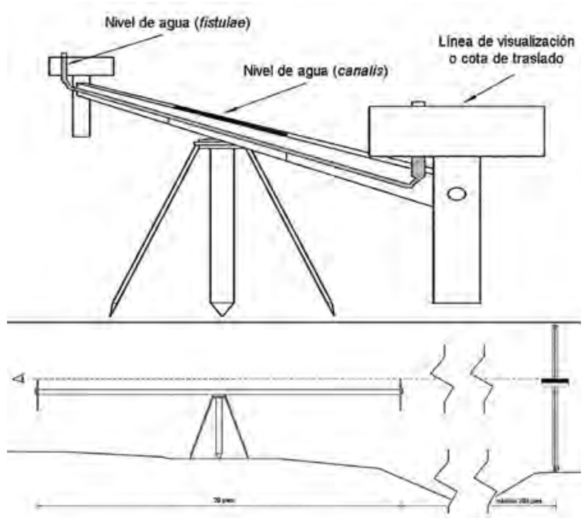

Fig. 6. Operation scheme of a chorobates described by Vitruvius. Reconstructed, tested and patented by the author in 2004. 'The chorobates is a straightedge about twenty feet long. At the extremities it has brackets, made exactly alike and jointed onperpendicularly to the extremities of the straightedge'*. Vitr.* De arch. *8.5.1. (drawing author).*

Conclusions

We still have to discover many Roman aqueducts whose features will amaze us again. Many of the techniques that Romans applied still remain unknown and hidden in the absence of a rigorous analysis of these works. We still do not know if the elevation of water by mechanical means was common in Roman water supply. Despite the low profitability of this solution, particularly in a civilization whose technology allowed water to be led by gravity to incredibly high places, we have found large water reservoirs located tens of meters above the arrival height of the impressive Roman rock-cut channel in the Roman city of *Vxama*.[24]

The relation between the various reservoirs that have been found and the different channels (whether known or unknown) has not been resolved in most Roman cities where at least some of the other elements of the aqueduct have appeared. In other cases, the location of the sources or the alignment of most of the channel has not been identified. There is still no answer to any of these questions for the vast majority of Roman cities. Only a high level of scientific and technological knowledge could allow the fulfilment of these achievements.

Therefore, an engineering approach into the analysis of Roman public works is deemed essential. Without this approach, we will never get to fully understand the Roman civilization.

Notes

1 Plin. *Nat.* 31.4.
2 Vitr. *De arch.* 8.
3 Feijoo Martínez, 2005.
4 Vitr. *De arch.* 8.3.
5 Pall. *Agric.* 1.4.
6 The related literature, as it happens with other structures, dates almost all ancient dams as from the Roman time, although there is no document that could assign their origin to a determined time. To summarize, you can see the large number of supposedly Roman dams, although the one of Muel has been omitted, included in the work: Díez-Cascón Sagrado/Bueno Hernández 2003.
7 Hereza et al. 1996.
8 Feijoo Martínez 2005.
9 Mezquíriz Irujo 2004, 287-318.
10 Aranda Gutiérrez 2006.
11 Castillo Barranco/Arenillas Parra 2002.
12 Plin *Nat.* 31.31.6.1.
13 Moreno Gallo 2010.
14 Durand-Claye 1978.
15 Leveau 2006, 93-108.
16 Giorgetti 1985, 37-107.
17 Plin. *Nat.* 31.21.31.34.
18 Moreno Gallo 2004, 25-68.
19 Moreno Gallo 2004, 25-68..
20 Issue mentioned by Vitr. *De arch*. 8.5.3.: '*Perhaps some reader of the works of Archimedes will say that there can be no true levelling by means of water, because he holds that water has not a level surface, but is of a spherical form, having its centre at the centre of the earth.*'
21 Moreno Gallo, 2006, 357-367.
22 Moreno Gallo 2004, 25-68.
23 Perrault, 1673.
24 García Merino, 2006.

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Der vorliegende Band ist bereits die dritte von Gilbert Wiplinger herausgegebene Publikation eines Frontinus-Symposiums als BABESCH-Supplementband zur historischen Wasserwirtschaft. Schon nach dem Symposium "Cura Aquarum in Ephesus" (BABESCH-Suppl. 12) im Jahr 2004 zeichnete sich die Umgebung von Antalya durch die vielen spektakulären antiken Wasserbauten als Wunschziel für eine weitere Tagung ab. Aber erst am Ende des Symposiums "Historische Wasserleitungen. Gestern - Heute - Morgen" (BABESCH-Suppl. 24) 2011 in Wien sprach Havva İşkan-Işık, Professorin an der Akdeniz Universität Antalya, in der Abschlussdiskussion die Einladung nach Antalya aus, sodass diese 2014 realisiert werden konnte.

Der Titel des Symposiums "DE AQUAEDUCTU ATQUE AQUA URBIUM LYCIAE PAMPHYLIAE PISIDIAE - The Legacy of Sextus Julius Frontinus" entstand aus der engen Verbindung Antalyas mit diesen drei antiken Landschaften und der intensiven Auseinandersetzung mit der Schrift des Sex. Julius Frontinus - De aquaeductu urbis Romae - deren Neuauflage durch die Frontinus-Gesellschaft im Jahr 2013 erfolgte.
In diesem Band werden 31 Vorträge publiziert, die z.T. mit dem Exkursionsprogramm im Verlauf des vom 31. Oktober bis. 9. November stattgefundenen Symposiums eng verknüpft sind. Die Beiträge folgen dem Tagungsverlauf mit unterschiedlichen Schwerpunkten.

Nach den Eröffnungsvorträgen über "Ingenieure im Dienst der Archäologie am Beispiel der Fernwasserleitungen von Ephesos" und "Inschriften auf römischen Wasserrohren" folgt als erster Schwerpunkt mit überwiegend aus der Region stammenden Fernwasserleitungen und innerstädtischen Leitungssystemen. Diese Leitungen sowie die damit verbundenen Systeme in Side, Aspendos, Phaselis und Patara wurden auf Exkursionen besucht. Darüber hinaus kommen sowohl andere Regionen Anatoliens als auch des übrigen Römischen Reiches (Alba Fucens in Italien, Cadiz in Spanien) zur Sprache. Einen anderen landesbezogenen Schwerpunkt bildet Jordanien. Zwei Beiträge zeigen an den Beispielen Petra und Gerasa Lösungen der Wasserversorgung in ariden und semiariden Gebieten.

Die weiteren Beiträge sind nach thematischen Schwerpunkten gegliedert. Der erste beschäftigt sich mit Zisternen, die in Patara und Termessos vor Ort studiert werden konnten.

Der nächste Themenkomplex behandelt bauliche Strukturen römischer Badeanlagen von Italien (Baia) über die Türkei (Patara) bis Israel (Caesarea Maritima). Untersucht werden zudem Todesfälle antiker Herrscher in Bädern.

Zwei weitere Beiträge befassen sich mit sehr unterschiedlichen Themen. Einmal geht es um die private Nutzung von Wasser im östlichen Mittelmeerraum und zum anderen um dessen religiöse Verwendung in Rom selbst.

Im nächsten Themenschwerpunkt geht man hydrotechnischen Problemen auf den Grund. Diskutiert werden nicht nur theoretisch, sondern auch vor Ort die Talentwässerung von Bezirgan, der komplizierte Siphon von Aspendos und die Frage der Fließgeschwindigkeit in Nymphäen u.a. an Beispielen aus Sagalassos.

Der letzte Schwerpunkt setzt sich mit der industriellen Nutzung des Wassers auseinander, in dem Wassermühlen in Palästina, Bergwerke in Spanien und spätantike Rohre in Ephesos untersucht werden. Den Abschluss bildet der Ehrenvortrag von Marc Waelkens über Sagalassos, die Stadt des Wassers.

Ergänzt wurde das Programm durch die Verleihung der Frontinus-Medaille an verdiente Forscher im Bereich der Wasserwirtschaft: Isaak Moreno Gallo (Spanien) und Ünal Öziş (Türkei). Deren Leistungen spiegeln sich in den ebenfalls in diesem Band vorliegenden Laudationes wieder.

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