

Sophie Bouffier, Vincent Dumas, Philippe Lenhardt, Jean-Louis Paillet

HYDROSYRA Project. Some Reflections about the Ancient Aqueduct of Galermi (Syracuse, Italy)

Summary

Since 2012, the Centre Camille Jullian team carries out an interdisciplinary study of the aqueduct Galermi, architectural work and hydraulic engineering of about 30 km long. This aqueduct, built between the 5th century BC and the Roman Empire, first supplied drinking water to Greek and/or Roman Syracuse. In the 16th–17th centuries, partial transformations have been done and changed the function of the channel, with the installation of flour mills. In the 19th century, the new Italian state gradually expropriated immediate neighbors who exploited abusively the aqueduct. It was then devoted only to irrigate the Syracusan territory according to a system of concessions that has almost remained unchanged since the 19th century. The paper will present this program and the last results that the team obtained in the last two years, particularly about intakes of water and underground galleries, and which chronology can be proposed.

Keywords: Aqueduct; Greek and Roman Antiquity; drinking water; Sicily

Seit 2012 führt das Zentrum von Camille-Jullian eine interdisziplinäre Studie zum Galermi-Aquädukt, seiner Architektur und hydraulischen Technik auf ungefähr 30 km Länge durch. Dieses Aquädukt, gebaut zwischen dem 5. Jahrhundert v. Chr. und dem römischen Reich, lieferte zunächst Trinkwasser zum griechischen bzw. römischen Syrakus. Vom 16. bis 17. Jahrhundert sind partielle Umwandlungen getätigt worden, die die Funktion des Kanals durch die Inbetriebnahme von Getreidemühlen änderten. Im 19. Jahrhundert dann eignete der neue italienische Staat stufenweise Anrainer, die das Aquädukt-Wasser illegal angezapft hatten. Das Wasser kam somit vollständig dem syrakusischen Gebiet zu und die entstandenen Konzessionen behalten bis heute ihre Gültigkeit. Der Aufsatz wird diese Geschichte und neueste Forschungen präsentieren, die sich in den letzten zwei Jahren besonders mit der Aufnahme unterirdischer Wassergalerien und der Erstellung einer Chronologie beschäftigt haben.

Keywords: Aquädukt; griechische und römische Antike; Trinkwasser; Sizilien

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Since 2012, the Centre Camille Jullian (Aix-Marseille University) has carried out an interdisciplinary study of the Galermi Aqueduct, a work of hydraulic engineering about 30 km long that is situated in the Province of Syracuse (Fig. 1).

This aqueduct, which was built between the 5th century BC and the Roman Empire, supplied drinking water to Greek and/or Roman Syracuse. In the 16th–17th centuries, partial transformations of the aqueduct were made, including the creation of new water intakes and the installation of flour mills, which changed the function of the aqueduct. In the 19th century, the Syracusan Senate recovered the control of the aqueduct from the aristocratic Gaetani-Specchi family; the new Italian State then gradually expropriated the immediate neighbors who had exploited the aqueduct abusively. They then devoted the aqueduct to irrigating the Syracusan territory according to a system of concessions that has remained almost unchanged since then (Fig. 2).

This shift promoted the implementation of an agrarian economy and a specific landscape: as it runs through an arid area, it has created a green zone of citrus fruits and plantations all along its sides because tanks and pipes have been installed on its course. From 1924 to 1967, it has also been used to operate one of the first hydroelectric firms in the region: Salonia e Carpenteri firm. Like other investors, these entrepreneurs bought land in 1923 to benefit from the close aqueduct and diverted its waters into a channel to run an electrical turbine. Technical responsibility for the aqueduct was given to Genio Civile under the supervision of the Syracuse Soprintendenza ai Beni Culturali. The aqueduct is still the center of the political and economic management of a Mediterranean country and the heart of debates about Sicilian and Mediterranean water policies. Comparative studies of other similar water transportation systems in the cities of Agrigento and Palermo, and in the countries of Spain and Portugal, highlight shifts in traditional practices. The project HYDROSYRA intends to explore the various facets of the aqueduct to

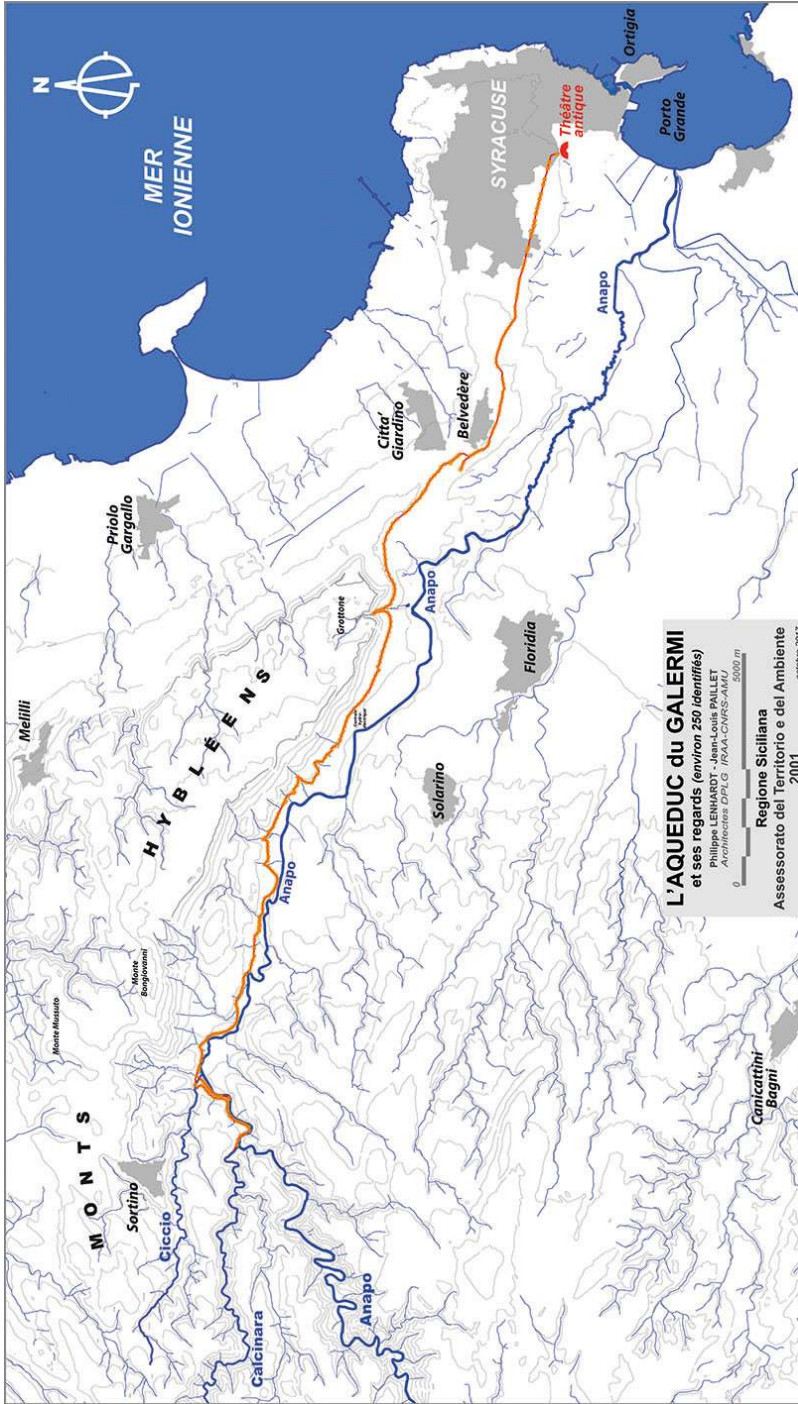


Fig. 1 Location of the Galermi Aqueduct (in orange colour on the map)



Fig. 2 The irrigation system: Fig. 2a: on the left, private reservoir for storing irrigation water. Fig. 2b on the right, Regulatory tank of irrigation, under the supervision of Genio Civile.

allow us to understand the control strategies implemented and the management of water resources of this territory in Sicily from a case study perspective. Inherently interdisciplinary, the project draws upon the expertise of several humanities and social science disciplines: geomorphological and paleo-environmentalism, archaeology, architecture, history, and anthropology.

After providing a general presentation of the aqueduct, this paper focuses on the knowledge that the team obtained regarding this ancient monument after field missions conducted between 2012 and 2016. We have been able to highlight the digging strategies of the engineers and the hydraulic technology in sectors that have been the least affected by recent repairs. Now it is possible to propose some dating to the different stages of use of the channel and underline its specificity.

I State of the art

I.1 Chronology of the aqueduct

One of the main problems being addressed is that the chronology of the aqueduct is challenging to determine. Actually, like all the hydraulic structures, it has been regularly cleaned from Antiquity to nowadays, and the sediments and traces of human frequentation and occupation have been removed during the cleaning phases; so it is difficult to accurately identify and date the different interventions.

For a long time, historiography knew several aqueducts in Syracuse and discussed

their chronology and sponsor¹. About the Galermi Aqueduct, the problem is more complex because the aqueduct has been used for more than 2000 years. The first unknown date is when the Syracusans excavated and created the structure, with scholars holding conflicting views. The other ones concern the different repairs of the monument. According to Julius Schubring, a German historian of the 19th century who wrote a number of papers about water management in the Sikeliot cities, the Galermi Aqueduct could have been established during two periods: before the tyrant Gelon, that is to say before 485 BC, or during the autocratic rule of Dionysius the Elder, between 405 and 367.² Francesco Saverio Cavallari and Adolf Holm set up the first scientific plans of the Syracusan aqueducts in 1883. They proposed to date these aqueducts before the Sicilian expedition in 415 BC.³ In Sophie Collin Bouffier's PhD about water in Greek Sicily⁴ and several papers she wrote,⁵ she discussed several dates of creation for the aqueduct: the contracting authority could be Dionysius the Elder between 405 and 367, Timoleon between 344 and 337, or Hiero the Second between 289 and 216. Collin Bouffier took no position on the dating, based upon the poverty of information available at the time her works were written. Some quick architectural studies have been carried out that have not resulted in anything novel in regard to the chronology of the aqueducts.⁶ Roger A. Wilson, at the congress of the Frontinus Gesellschaft *Cura aquarum in Sicily* in 1998, proposed dating the aqueducts to the Roman period.⁷ The latest investigations continue to highlight the questions surrounding the dating of the aqueducts.⁸

1.2 Ancient writers

The Syracusan aqueducts have been known since the 5th century BC, when Thucydides evoked the Athenian expedition in 415–413; he noted that the Athenians cut underground pipes that were established to provide the city with drinking water.⁹ Later texts

1 Collin Bouffier 2001.

2 Schubring 1865, 625–28.

3 Cavallari and Holm 1883, 106, note 1.

4 Collin Bouffier 1992.

5 Collin Bouffier 1987, 278–280; Collin Bouffier 2001; Collin Bouffier 2009, 73–74.

6 Crouch 1993.

7 Wilson 2000.

8 Sophie Bouffier, Julien Curie, Christophe Petit, and Cees Passchier. "Laqueduc grec du Galermi à Syracuse, Sicile." In *Les dépôts carbonatés en contexte archéologique. Une mémoire de la gestion de l'eau, Journées d'études géoarchéologiques 18–19 septembre 2014, Maison Archéologie et Ethnologie – René Ginouvès*. Ed. by J. Curie, C. Petit, and C. Passchier. Nan-

terre: Maison Archéologie et Ethnologie – René Ginouvès, forthcoming. Sophie Bouffier, Vincent Dumas, Philippe Lenhardt, and Jean-Louis Paillet. "Nouvelles recherches sur l'aqueduc du Galermi." In *Politiques et techniques hydrauliques en Méditerranée préromaine, HYDROMED Symposium II, Università di Palermo, décembre 2015*. Ed. by S. Bouffier, O. Belvedere, and S. Vassallo. Aix-en-Provence: PUP, forthcomingb.

9 Thuc. *The Peloponnesian War*, 6.100: "Meanwhile the Athenians destroyed their pipes which ran underground into the city and supplied it with drinking water." ("οἱ δὲ Ἀθηναῖοι τοὺς τε ὀχετοὺς αὐτῶν, οἱ ἐς τὴν πόλιν ὑπονομηδὸν ποτοῦ ὕδατος ἡγμένοι ἦσαν, διέφθειραν.") <http://www.perseus.tufts.edu/>

by Servius (from the 4th century AD) seem to refer to an aqueduct of the city, when he talks about a ditch that was dug by prisoners of war and filled with the water of a river. He noted that these prisoners were Athenian and Carthaginian captives after a defeat which is not dated.¹⁰ This ditch has been interpreted by Schubring as one of the Syracusan aqueducts: according to him, Servius was confused regarding the Athenian and Carthaginian prisoners, and these aqueducts had been dug after the battle of Himera in 480 BC, as was the case in Agrigento.¹¹

If we look at the historical context, aqueducts existed in several major Greek cities, in Sicily in Agrigento, as noted in Diodorus Siculus, and in Samos,¹² Athens,¹³ Corinth,¹⁴ and Megara,¹⁵ identified from archaeological ruins.¹⁶ The major cities of the Aegean world were equipped with water supply installations, fountains, and pipes of drinking water¹⁷ from the beginning of the 6th century BC (maybe even from the 7th century BC) until the Hellenistic period. Some of them were established under tyrannical regimes that, according to Aristotle,¹⁸ were intended to divert the people from their aspirations of freedom. In actuality, though, most of the Greek aqueducts were designed in cities that were experiencing an economic boom, during times that corresponded to development of the urban centers that improved the living conditions of the populations, in

hopper/text?doc=Thuc.+6.100&fromdoc=Perseus%3Atext%3A1999.01.0199 (visited on 25/05/2018).

- 10 Serv. *Aen.* 3.500: "At that time, the Syracusans, victors of the Athenians, took a huge number of prisoners at Syracuse, and made them increase the defence of the city by breaking the mountains. Then, as the walls had been extended, they also dug inside the rampart a ditch that was filled with the water of the river to reinforce the city. This ditch, that had been realized thanks to the punishment of the enemy for the damages they caused, they called it Thybris." ("Quodam tempore Syracusani, victores Atheniensium, ceperunt Syracusis ingentem hostium multitudinem et eam caesis montibus fecerunt addere munimenta civitati. Tunc auctis muris etiam fossa intrinsecus facta est, quae flumine admisso repleta munitiorem redderet civitatem. Hanc igitur fossam, per hostium poenam et iniuriam factam, Thybrin vocaverunt"). Serv. *Aen.* 8.330: "The poet called Tiberis Tybris compared with the Syracusan ditch that has been dug near the rampart of the city by Africans and Athenians because of the damages they caused" ("Tiberis Tybrin poetam dixisse ad similitudinem fossae Syracusanae quam fecerunt per iniuriam Afri et Athenienses iuxta civitatis murum.")
- 11 Diod. Sic. *Bibliotheca historica*, 11.25. "Most of them

[the Carthaginian captives] were handed over the state, and it was these men who quarried the stones of which not only the largest temples of the gods were constructed but also the underground conduits were built to lead off the waters from the city: these are so large that their construction is well worth seeing, although it is little thought of since they were built at slight expense. The builder in charge of these works, who bore the name of Phaeax, brought it about that, because of the fame of the construction, the underground conduits got the name "Phaeaces" from him. The Acragantini also built an expensive kolumbethra, seven stades in circumference and twenty cubits deep", 13.82.

- 12 Kienast 1995.
 13 Camp 1980; Tölle-Kastenbein 1994.
 14 Hill 1964; Robinson 2011.
 15 Panagiota Avgerinou. "Investigation of the Ancient Underground Aqueduct in Megara: Preliminary Results". In *Politiques et techniques hydrauliques en Méditerranée préromaine, HYDRQMED Symposium II, Università di Palermo, décembre 2015*. Ed. by S. Bouffier, O. Belvedere, and S. Vassallo. Aix-en-Provence: PUP, forthcoming.
 16 Arnone 1952.
 17 Tölle-Kastenbein 1990.
 18 Arist. *Po.* 1313a–b.

particular, improving public health. In Sicily, the victory of the tyrants, Gelon of Syracuse and Theron of Agrigento, over the Carthaginians at Himera in 480 BC fits into an era of urban upheaval that led them to the realization of large-scale hydraulic works, like aqueducts and the basin of Agrigento (the famous *kolymbethra*), as explained by the historian Diodorus Siculus.¹⁹

1.3 Fazello and other modern scholars

Since the 16th century, scholars and travelers in Sicily have confirmed the existence of aqueducts that they have described in a way that is more or less succinct and realistic. The most complete and detailed list of Syracusan works was been compiled by Tomaso Fazello in 1558. His work, written first in Latin (*De rebus siculis, descades duae, nunc primum in lucem editae*. 1st ed. Palermo, 1558) was translated into Italian in 1628.²⁰ It described the aqueducts as follows:

As freshwater of this land was limited, Syracusan people dedicated their ingenuity and financial resources to excavate underground aqueducts, as we do nowadays; these aqueducts were perforated in depth and had the dimensions of a regular-sized man. And so that the water meets no obstacle and can be drawn easily by everybody in town, they excavated a lot of openings in different points, used as wells [...] Nearly twenty milia far from Syracuse westward, there is a big valley, which has a modern little castle named Sortino [...]. From there gushes some huge and abundant spring, which name is Guciuno nowadays; right away it becomes a river which flows some hundred paces and grows thanks to the arrival of two others springs, the one called Argentino, the other Rugio; the first is coming from the left bank and is named after its sands, which seems to be silver; the other one is coming from the right side; below the castle, there is another spring, called Primo, which flows into the other ones. Above Sortino, there is a hill, nowadays called Serramenzano. [...]

At its bottom, south, at the beginning of a valley situated between Pantalica and the city of Serramenzano now destroyed, which was called Herbessos in Antiquity, two other spring gurgle very abundantly: they are commonly called Buttigliarie nowadays, and form immediately a genuine river. From there Syracusan people, for lack of water, were forced to dig an underground channel and bring it up to the city with considerable effort and expense. It is called nowadays channel of ‘the beautiful woman.’ [...]Then thanks to numerous aqueducts,

19 Collin Bouffier 2000.

20 Fazello 1628, 72–96.

partly consisting in masonry, partly excavated underground, they led a lot of water to the city, nearly 20 milia far away: we can see still now many remains of these aqueducts. Then these channels at the time in which the Athenians were fighting against the Syracusans, were cut off to deprive the besieged of water, so that they should have to surrender because of the lack of water, according to the narrative of Thucydides in the 6th book. And as the channels are cut off, these water discharge in the river Anapo [...]

Theater in Napoli of Syracuse: it was surrounded all around with big walls which have been built in huge cut blocks, and it had, in the part toward Tica, one spring which was flowing from underground channels, very crafty excavated; this spring lost its once name and is called now from Saracen language 'Garelme,' that means in our language, hole of water, and nowadays is called Galermo by linguistic deformation.

His description is an essential starting point for a number of reasons. The first reason is that Fazello listed some monumental waterworks in urban areas, such as those in Trimilia, Garelmo, and Paradiso in the South and Targiuni, Targia, Bosco, and Targeta in the North. According to him, it is not possible to identify their intakes even if most people think that they come from Monte Climiti in the northwest hinterland. Another aqueduct, called 'Bella Femina' came from Sortino and was supplied by two main streams: Buttigliarie (oggi Bottiglieria o Calcinara, because it brings calcite), which is a tributary of the Anapo River, and the Guccio, another tributary of the Anapo River that is today called Ciccio. These rivers arose from karstic springs. The 'Bella Femina' is the aqueduct that is today called Galermi. From there, they created a lot of aqueducts, some built above ground and some completely underground. In the 16th century, these aqueducts could be seen, but that is often no longer the case.

As well as describing the channel, Fazello provided an important indication about its chronology. He visited the channel before 1576, the date of attribution of the monopoly of exploitation of the Marquis Gaetani of Sortino by the Syracusan Senate, and before the earthquake of 1693, before the big transformations that were applied to the Galermi Aqueduct. So his description is likely of the ancient water channel. The technical typology that we know from Fazello is that: an underground channel was dug into the limestone cliff; there was an arched bridge over the Anapo River, which still exists today; and there were several water intakes. Today, we know only the underground channel that was reconstructed and repaired over five centuries.

After Fazello, some local scholars proposed the first archaeological maps of the city²¹

21 Mirabella and Alagona 1613; Capodieci 1813.

and the first inventories of Syracusan monuments²² by repeating each other.

1.4 19th century historians and archaeologists

Among scholars, Schubring wrote the first summary about water management in the Greek city of Syracuse; in his work, he mostly agreed with Fazello.²³ According to him, all Syracusan water pipes came from the Monte Climiti and crossed underneath to the Ortygia Island. He calls the aqueduct of Galermi 'Anapo'. Fazello indicated that the aqueduct had two water intakes, drawing water from the Bottiglieria and the Santa Sofia/Ciccio River, that he called 'Guccio'. Then the aqueduct was completely underground and would have followed the Anapo as it meandered to the Syracusan shelf, where it passed south of Belvedere Village to a site called Buffalaro, where it fed two tanks before arriving into the city just north of the theater. According to him, the structure of the aqueduct cannot be traced after the area of the theater, in the vicinity of Contrada Zappalà, where Hellenistic baths were excavated in 1938.²⁴

A few works discuss Syracusan aqueducts in more precise detail, even if they were not the focus of the work itself; Cavallari and Holm's *Topografia archeologica di Siracusa*²⁵ provides scientific information and topographical maps. From these sources, they calculated that the aqueduct was 29.5 km long with a slope of 0.5%. At what is now the Casa dell'Acqua, the aqueduct split into two channels: one powers the Nymphaeum today and the other goes towards the eastern part of the city. The two authors described the typology of the aqueducts as entirely dug and opencast built, in *opus incertum* or in irregular blocks, and covered with slabs of stones. However, this peculiarity has since been attributed to modern repairs, as the two authors had suspected.

2 New investigations

We distinguish three various phases of the Galermi Aqueduct: the ancient; the modern, from Gaetani times; and the contemporary, after Italian Unity. Our primary mission has been to work to understand the water intakes, the layout, and progression of the aqueduct.

22 For example Logoteta 1788.

23 Schubring 1865.

24 Cultrera 1938, 261–301.

25 Cavallari and Holm 1883; Cavallari 1891.



Fig. 3 The Ciccio niche and water intake.

2.1 The water intakes

Nowadays, as in Fazello's time, the aqueduct's source stems from several places in the Hyblaeen Hills, which are about 30 km from the ancient city of Syracuse, via the tributaries of the Anapo River. There are at least four water intakes, including two that seem likely to be ancient and one that was created in the 19th century. One of the more ancient ones was created in the Ciccio River: it was carved into the limestone and presents a trapezoidal niche that still shows the remains of an inscription that is currently being decrypted. For the moment three Greek letters can be read: ι (iota), ε (epsilon), ω (omega) and maybe a fourth letter δ (delta), which form is certainly ancient, as we can deduct in contrast to another Greek inscription, which has been found in one of the openings and whose typology is clearly byzantine. The niche has been later coated by two coatings: a fresco and a thick mortar (Fig. 3).²⁶

The intake that is furthest from the city of Syracuse is the Bottiglieria; it recovers the water that has been stored in a dam (that seems to have been artificially made) on the Calcinara River (Fig. 4). A modern arrangement partially fills the entrance of the gallery, which prevents us from restoring the original typology. At a point where the stream broadens, before a vertical drop of around 5 m, the river forms a kind of tank (width 9 m and length around 20 m, for a surface 180 m²). Here, something like a dike has been created that blocks the full width of the stream. It is nearly impossible to restore

26 We have highlighted elsewhere that the intake has gone through several transformations. Sophie Bouffier, Vincent Dumas, Philippe Lenhardt, and Jean-Louis Paillet. "Nouvelles recherches sur l'aqueduc du Galermi". In *Politiques et techniques hy-*

drauliques en Méditerranée préromaine, HYDRΩMED Symposium II, Università di Palermo, décembre 2015. Ed. by S. Bouffier, O. Belvedere, and S. Vassallo. Aix-en-Provence: PUR, forthcomingb.



Fig. 4 The Calcinara water intake.

the initial form of the dam because of the limestone deposits that have transformed the site, but there are no other abrupt breaks of slope in the riverbed. It seems that those who constructed this dike exploited the natural slope of the riverbed and accentuated it by digging it deeper, to be ensure that the water would flow into the channel. A forebay opposite the intake of the aqueduct allowed the users to empty the dam in order to divert the water away from the channel. On the top of the dam, there are tracks of some rock-cuttings, which are visible on the map (Fig. 5): in case of overflow, they could be opened or closed and regulate the stream. A core drilling that is planned should help us to understand the configuration of this arrangement.

Actually, there is no comparison between this rudimentary work and sophisticated dams, such as those that we see in Greece from the Bronze Age, where we find the dams of Boedria and Thisbe in Boetia, of Kofini at Argos, Tiryns and Orchomenos, which

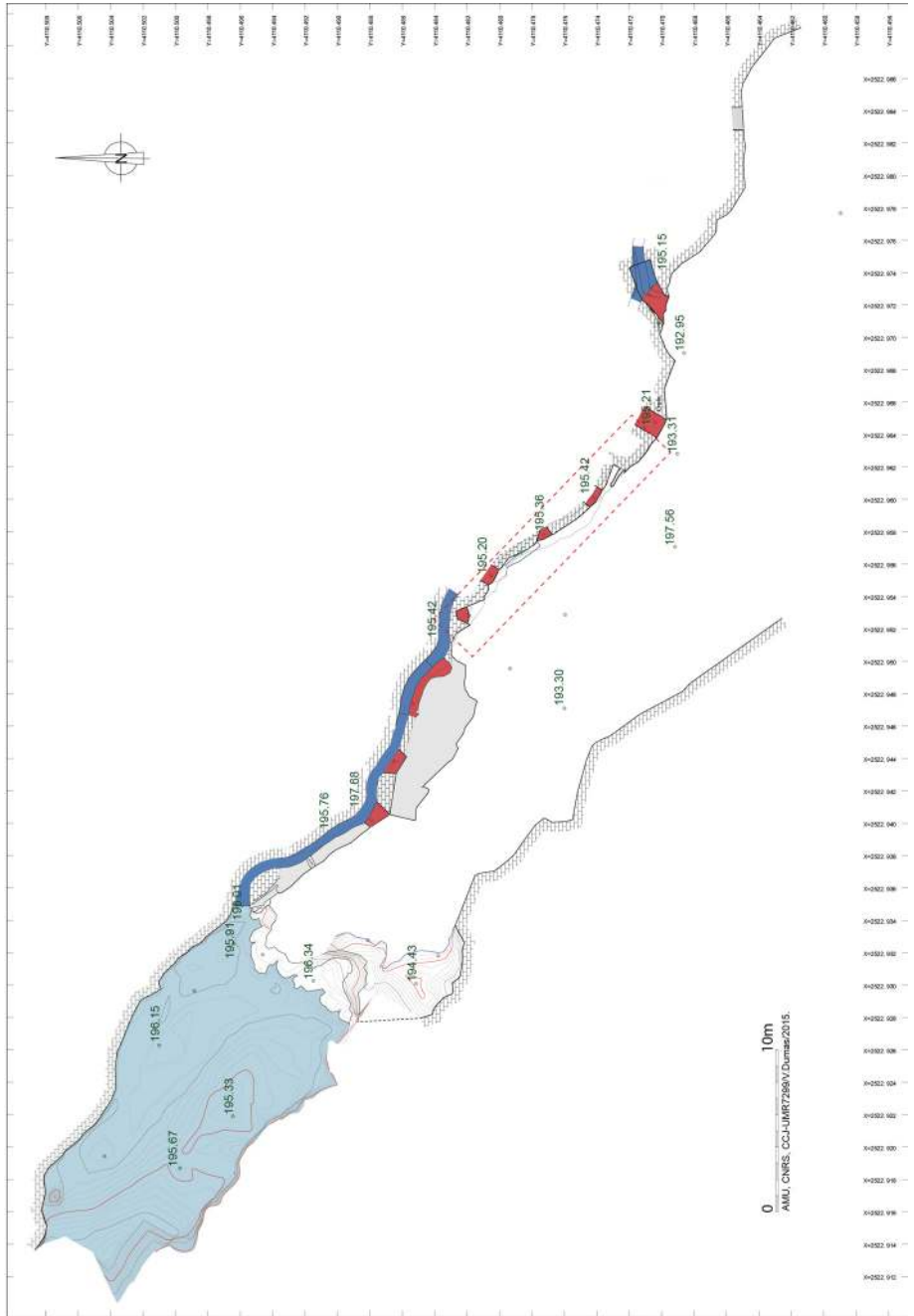


Fig. 5 Plan of the Calcinara water intake.



Fig. 6 Inscription of the Bottiglieria.

have been created for flood prevention,²⁷ and from Classical times at Delos, with the dam of the Inopos Reservoir.²⁸

When we know the origin of the water, as for the Eupalinos Aqueduct²⁹ and the Naxos Fleri Channels,³⁰ we can see that those who designed these systems utilized water caught in natural springs in a pond or a tank. In Roman times, even if those who constructed the structures rarely alluded to dikes in the construction of aqueducts, these kinds of water arrangement can be found in several of the aqueducts, such as the Glanum Aqueduct in Gaul.³¹ So the Bottiglieria water intake testifies a real mastery of hydraulic techniques, and is one of the rare examples of ancient dikes currently known.

The Bottiglieria water intake has another specificity: just inside the gallery, an inscription of five or six letters and symbols is deeply incised into the left pier (Fig. 6). At the moment, the inscription is difficult to read because of the calcareous deposits that have damaged it. It seems to present a Latin alphabet and further studies should be conducted to understand what was inscribed here more precisely and give us evidence of dating.

At least three other water intakes were established during the life of the structure: one that can be dated to the period following the concession of the waters to the Marquis Gaetani in 1576 (on the Anapo River, 2000 m after the Bottiglieria water intake); one established in 1921, which covered the preceding one because it was damaged by the floods of the Anapo River; and one established after 1953, to increase the capacities of irrigation of the channel that had been dedicated to land exploitation.

27 De Feo et al. 2012, 351–352.

28 Moretti and Fincker 2007.

29 Kienast 1995.

30 <http://www.hydraproject.info/en/> (visited on 27/10/2017) for example, <http://www.hydraproject.info/en/greece-naxos-ancient-flerion-aqueduct-importance13> (visited on 27/10/2017). Lambri-noudakis et al. 2017.

31 Agusta-Boularot and Paillet 1997.



Fig. 7 Track of the Aqueduct in the Hyblaean Mountains.

2.2 The track of the channel

After the Bottigliera water intake, the aqueduct runs along the valley of Calcinara and then along the Anapo River on a cliff that was carved directly into the limestone. It is uncertain if the track contained a clay or metal pipe for receiving the water. The channel adopts a zigzag path that is characteristic of the technique used for its construction (Fig. 7). The channel is 1.4 to 2.0 m in height and has a width of 0.4 to 0.8 m. In some places in the walls, cavities can be observed for the installation of lamps for the maintenance workers. The channel has several horizontal and vertical access shafts that were used for the digging of the channel and then for maintenance; there is no observable regularity of distance between these openings. In the parts near the Bottigliera, the space between these openings can vary from 2 to 13 m. The intervals seem to differ according to the slope of the cliff. The steeper the slope is, the greater the distance between two



Fig. 8 a and b: Some late inscriptions in the walls of the windows, c: Malta cross.

openings is. The width of the horizontal openings also varies from 0.9 to 1.35 m, and the height from 1.4 to 1.7 m. The dimensions of the vertical shafts have changed over history as they have been reused over the centuries. It is possible that those who constructed the channel excavated standard sized vertical shafts, and then the horizontal shafts were opened to extract the earth stemming from the excavation activities.

We also observed inscriptions in some access shafts. These inscriptions included crosses, sometimes oriental crosses, and symbols that remain to be decrypted (Fig. 8 a, c). Are these inscriptions simply signs of human presence and occupation in the times when they were made? Are they the marks of the tunnel and rock workers? We probably cannot assimilate all of them to the same process, as they are typologically and technically different. Some of them are only graffiti. Some refer to the use and transformations of the aqueduct. For example the Malta cross and another single cross have been cut at the point where we have identified a repair of the Gaetani period, in the 16th or 17th century (Fig. 8 a-b). In some Greek aqueducts that have been investigated, Greek letters have been interpreted as marks of the work of a particular mason, maybe in order to claim payment, as in Megara³² and Samos.³³ At the moment, as we do not have investi-

32 Panagiota Avgerinou. "Investigation of the Ancient Underground Aqueduct in Megara: Preliminary Results". In *Politiques et techniques hydrauliques en Méditerranée préromaine*, HYDRQMED Sympo-

sium II, Università di Palermo, décembre 2015. Ed. by S. Bouffier, O. Belvedere, and S. Vassallo. Aix-en-Provence: PUP, forthcoming, 44

33 Kienast 1995, 193-194.

gated a long part of the aqueduct, it is difficult to give an explanation of these marks.

After the Anapo Valley, the aqueduct runs through different geological levels and is entirely underground. The channel is at times carved into the rock and covered by slabs. Sometimes the channel is completely excavated underground, as in Contrada Sinerchia, or excavated in the sedimentary ground, requiring those who constructed it to fit in masonry walls in order to prevent collapse and water damage, which remain threats during the rainy season even today.

This is the part that has undergone the most repairs over time. While we have not studied this part physically yet, we can identify that a lot of work has been done on the track based on the Archives from the 19th century. Beyond that, however, it is difficult to draw any conclusions at this state of our research.

When one travels down into the plain, we observe vertical shafts at more or less regular intervals. The typology of these manholes is not homogeneous and we will reflect to see if it is possible to date them more precisely.

Based upon the points where we were able to make calculations, we found that the slope of the channel is irregular. At the water intake at Bottiglieria, the slope is greater than 7%, while in the Grottone area, it is about 0.02%. No conclusions can be drawn yet though, as the research is still ongoing.

Finally, though today the aqueduct reaches the Nymphaeum of the theater, it was not probably the case in antiquity, which will be the next focus of future study.

3 Some problems

The long life of the aqueduct and the numerous repairs and transformations that have been realized along its course have left testimonies of the technological knowledge of the past, some of which we present below. We will start by looking at the part of the channel that was dug into the Hyblaeon Cliff, where we noticed some anomalies that testify to the digging techniques used there, and we will then conclude with the problem of the siphon.

3.1 Side-by-side Channels

A few meters after the water intake at Bottiglieria, there are two channels that run alongside one another, side-by-side (Fig. 5 and 9): the upper channel, where water is still flowing, and the lower channel that is about 2 m below the upper channel, which has nearly disappeared.

The lower channel, running off the cliff, is 2 m high at the most and 0.5 m wide at



Fig. 9 The side-by-side channels.

its widest. The upper channel, running inside the cliff, has a lower height of 1.5 to 1.7 m and rests at a right angle behind the lower channel. On the external face of the cliff, we have the impression that the channel was closed with blocks, as in the internal face, the wall does not seem to have been dug. How can we explain this anomaly? First, we conceived two possibilities:

- Those who constructed the channel experienced difficulties during the digging and the carvers, who were working from two opposite ends of the channel and working towards one other, mistook the calculation of the slope, with one going too high, compared to the other one. Observations from inside the channel show that the top of the ceiling decreases extremely. Based upon this theory, the change to the higher channel could be the consequence of a quick remodeling.
- The lower gallery was the only original channel, but the channel was eventually covered by mud and dirt from the river during the winter floods, and the water was polluted. The channel could have even been damaged. They then decided to carve another channel at a higher level, where the floods would not reach.

Actually, the last field campaigns allowed us to date the transformation during the Gaetani period, so after the 16th century, thanks to the Malta cross which has been engraved at the starting point of the repair.

3.2 The preexistent chamber

About 12 m after the intake, as the crow flies, the channel crosses a more or less rectangular structure, a kind of room (3,65 m²) which has been carved in the limestone

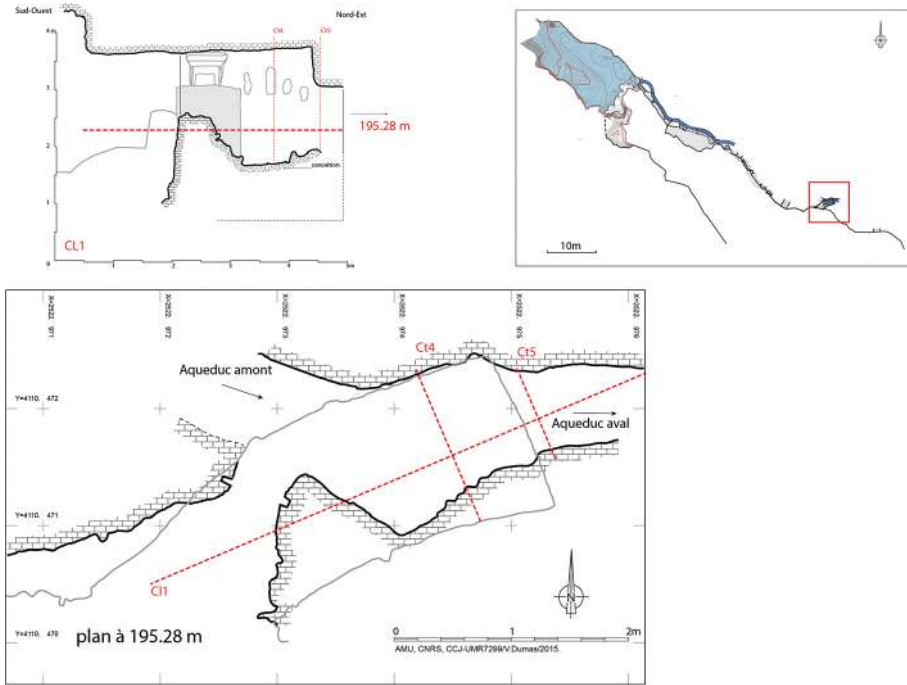


Fig. 10 Plan and elevation of the chamber.

before the aqueduct. Above the door jamb of the channel there is a decorated bas-relief (Fig. 10). It is a frame with a pediment for receiving a pillar *pinax* that would be attached via hinges or hooks (Fig. 11), as can be seen from the holes dug at the middle of the bas-relief.

Can we think of a layout recording a form of consecration of the water channel, as is the case in other water intakes?

This is unlikely, if we consider the location of the relief. Resting about 50 m from the water intake, it is located in a room that contains a bench that has been carved into the passage of the canal. Actually, it appears as though this room has no relation to the aqueduct. In addition to this bas-relief, there are other suspension holes on the other walls of the room, which are more difficult to understand. The pediment is characteristic of the Hellenistic period, and more precisely, at a time period after the 4th century BC. This kind of pediment spread during Roman times, as evidenced by the assumed tomb of Archimedes.³⁴

34 Ciancio 1965.



Fig. 11 The pediment of the chamber where a pillar *pinax* would be attached.

At first sight this structure seemed to be a burial chamber, which was a tradition in nearby Pantalica or Akrai, a sub-colony of Syracuse. Actually it was a tradition in the Bronze Age, no more at the Hellenistic period to which belongs the monument. It is more likely that this chamber is a cave shrine, dedicated to some god or goddess linked to the river, the mountains, or the wild land. No matter its function, it helps provide a clue for dating the channel.

3.3 The question of the siphon

The existence of a siphon would have been a good indicator for the date of the channel, as siphons did not appear in the Mediterranean world before the Hellenistic period. If the Galermi Aqueduct was created by Gelon or some tyrant before the Athenian Expedition in 415 BC, it could not have a siphon.

The channel had to cross several deep thalwegs, particularly the so called Grottone: the aqueduct has to cross a vertical drop of about 25-30 m. We could presume the presence of a siphon; however, the general survey and the speleological exploration have revealed that, in the first section, the channel follows the slope to the bottom of the valley before crossing it under the rock slopes without using a siphon. Two quadrangular manholes punctuate the peaks of the eastern and western slopes of the valley that are symmetrical in placement and similar in terms of their dimensions. Their depth exceeds 20 m and there is no longer water in the channel today, though some shafts that are located before and after this point are full of water. Following a landslide or collapse that we cannot date at the moment, the channel was closed by a wall and a pass-by was installed to permit the channel to cross the valley (Fig. 12).

So exploring this specific part of the aqueduct as much as other parts that present an important slope, we can deduct that there are no siphons in this hydraulic structure.

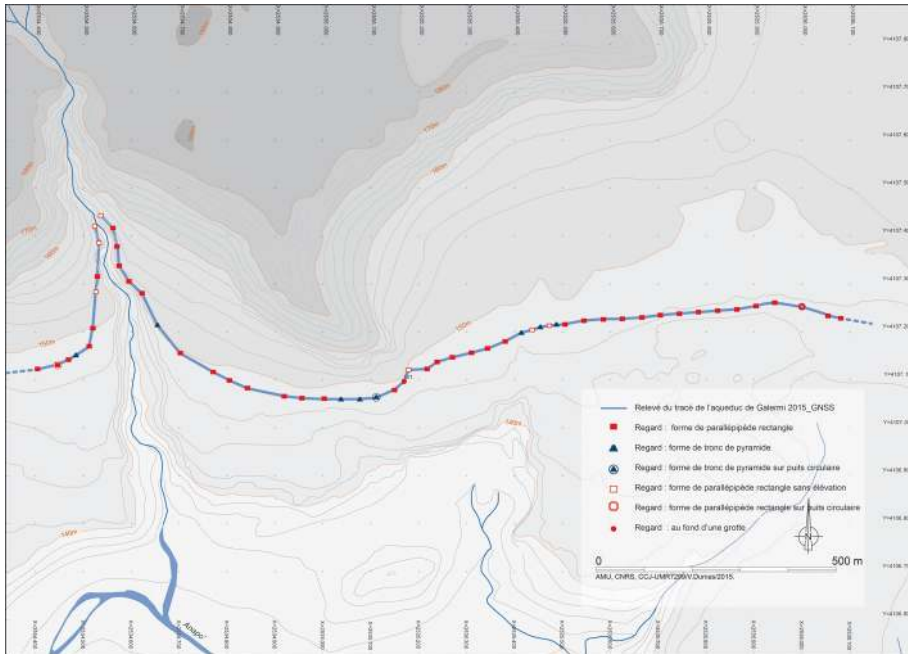


Fig. 12 The crossing of the Grottone Valley.

That evidence is a clue of a high-dating of the monument.

4 Conclusion

To conclude, in this research program, we have already gained some insights that can help us answer the essential question of dating the aqueduct: when was the aqueduct constructed, and by whom? At this point, typology and the apparent lack of technological requirements – the absence of a siphon, the very irregular course of the channel– might suggest a fairly early date, that is to say during the Classical period or at the end of the Archaic period. The relief of the pediment and the presence of an ancient bridge that allows the aqueduct to cross the Ciccio River, however, forced the chronology later than what we had originally thought. If the Athenians destroyed some channels, it was not the Galermi aqueduct, but presumably the so called Nymphem or Paradiso Channels. As the Ciccio inscription probably indicates this, the Galermi aqueduct seems to go back to the Hellenistic period between the 3rd and the 1st century BC. The person responsible for such a great structure could be Hiero the Second, who encouraged the

development of technology in his city and constructed several monuments of prestige in Syracuse; he was assisted in his efforts by the engineer Archimedes.

It should be noted that the absence of a siphon does not mean that those who constructed the aqueduct did not know the principles underlying the siphon. Actually, even Roman aqueducts have utilized channels that a track that ran along a slope over using a siphon, which is a typology that is rather fragile because it requires a great deal of accuracy when it comes to its maintenance. The continuation of our research program should provide us with more information about this work, which is rare in ancient Sicily, and give evidence to this hypothesis.

Bibliography

Agusta-Boularot and Paillet 1997

Sandrine Agusta-Boularot and Jean-Louis Paillet. "Le barrage et l'aqueduc occidental de Glanum: le premier barrage-voûte de l'histoire des techniques?" *Revue Archéologique* 1 (1997), 27–78.

Arnone 1952

Luigi Arnone. *Gli Ipogei dell'Agrigentino*. Agrigento: Edizioni Ente provinciale per il turismo, 1952.

Camp 1980

J. McKesson II Camp. *The Water Supply of Ancient Athens from 3000 to 86 B.C.* Ann Arbor, Michigan: University Microfilms international, 1980.

Capodieci 1813

Giuseppe Maria Capodieci. *Antichi Monumenti di Siracusa*. Syracuse: Presso D.F.M. Pulejo, 1813.

Cavallari 1891

Francesco Saverio Cavallari. *Appendice alla topografia archeologica di Siracusa*. Torino: C. Clausen, 1891.

Cavallari and Holm 1883

Francesco Saverio Cavallari and Adolf Holm. *Topografia archeologica di Siracusa*. Palermo: Tipografia del giornale Lo statuto, 1883.

Ciancio 1965

Salvatore Ciancio. *La tomba di Archimede: un sepolcro con colonnetta alle porte di Acradina*. Rome: IWA Publishing, 1965.

Collin Bouffier 1987

Sophie Collin Bouffier. "L'alimentation en eau de la colonie grecque de Syracuse. Réflexions sur la cité et son territoire?" *MEFRA* 99.2 (1987), 661–691.

Collin Bouffier 1992

Sophie Collin Bouffier. *Leau en Sicile grecque: réalistes et mythes*. PhD. Paris: Nanterre, 1992.

Collin Bouffier 2000

Sophie Collin Bouffier. "Quelles fonctions pour la kolymbethra d'Agrigente?" In *Cura Aquarum in Sicilia, Syracuse, 17–22 mai 1998*. Ed. by G. C. M. Jansen. BABESCH supplément 6. Leiden: Peeters Publishers, 2000, 37–43.

Collin Bouffier 2001

Sophie Collin Bouffier. "Les adductions hydrauliques des villes grecques de Sicile: des ouvrages techniques méconnus?" In *TEXNAI. Techniques et sociétés en Méditerranée*. Ed. by J.-P. Brun and P. Jockey. Paris: Maisonneuve et Larose, 2001, 513–528.

Collin Bouffier 2009

Sophie Collin Bouffier. "L'eau en Sicile grecque. Nouvelles perspectives de recherches?" *Pallas* 79 (2009), 65–79.

Crouch 1993

Dora P. Crouch. *Water Management in Ancient Greek Cities*. Oxford: Oxford University Press, 1993.

Cultrera 1938

Giuseppe Cultrera. "Siracusa. Rovine di un antico stabilimento idraulico in contrada Zappalà." *Notizie degli Scavi di Antichità* (1938), 261–301.

De Feo et al. 2012

Giovanni De Feo, Pietro Laureano, Larry W. Mays, and Andreas N. Angelakis. *Water Supply Management Technologies in the Ancient Greek and Roman Civilizations, Evolution of Water Supply through the Millennia*. London: IWA Publishing, 2012.

Fazello 1628

Tomaso R.P. Fazello. *De rebus siculis, decades duae, nunc primum in lucem editae*. 2nd ed. Palermo, 1628.

Hill 1964

Bert H. Hill. *The Springs. Peirene, The Sacred Spring, Glauke*. Corinth 1.6. Cambridge, MA: Harvard University Press, 1964.

Kienast 1995

Hermann J. Kienast. *Die Wasserleitung des Eupalinos auf Samos*. Bonn: Habelt, 1995.

Lambrinouidakis et al. 2017

Vassilis Lambrinouidakis, Alexandra Sfyroera, Themitoklis Bilis, Maria Magnisali, and Evangelos Kazolias. "The Ancient Aqueduct of Naxos". In *Cura Aquarum in Management and Hydraulic Engineering in the Mediterranean Region*. Ed. by K. Wellbrock. Vol. 27-2, sub-volume 2. Siegburg: DWhG, 2017, 377–394.

Logoteta 1788

Giuseppe Logoteta. *Le antiche Siracuse*. Catania: Presso F. Pastore, 1788.

Mirabella and Alagona 1613

Vincenzo Mirabella and Scoriggio Alagona. *Dichiarazioni della pianta dell'antiche Siracuse e d'alcune scelte medaglie d'esse*. Naples: Stampa di Lazzaro Scoriggio, 1613.

Moretti and Fincker 2007

Jean-Charles Moretti and Myriam Fincker. "Le barrage du Réservoir de l'Inopos à Délos". *Bulletin de Correspondance Hellénique* 131.1 (2007), 187–228.

Robinson 2011

Betsey A. Robinson. *Histories of Peirene: a Corinthian Fountain in Three Millennia*. Ancient Art and Architecture in Context 2. Princeton: American School of Classical Studies at Athens, 2011.

Schubring 1865

Julius Schubring. "Die Bewässerung von Syrakus". *Philologus* (1865), 579–638.

Tölle-Kastenbein 1990

Renate Tölle-Kastenbein. *Antike Wasserkultur*. Munich: C. H. Beck, 1990.

Tölle-Kastenbein 1994

Renate Tölle-Kastenbein. *Das archaische Wasserleitungsnetz für Athen [und seine späteren Bauphasen]*. Sonderhefte der Antiken Welt, Zaberns Bildbände zur Archäologie 19. Mainz: Philip von Zabern, 1994.

Wilson 2000

Roger A. Wilson. "Aqueducts and Water Supply in Greek and Roman Sicily. The Present Status Quaestionis?". In *Cura Aquarum in Sicilia, Syracuse, 17–22 mai 1998*. Ed. by G. C. M. Jansen. BABESCH supplément 6. Leiden: Peeters Publishers, 2000, 5–36.

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SOPHIE BOUFFIER

Aix Marseille Univ, CNRS, Minist Culture & Com, CCJ, Aix-en-Provence, France, Dr. in Greek history and Archaeology Paris Ouest-Nanterre 1992, Habilitation Aix-en-Provence 2004. She is the head of the project HYDROSYRA, interdisciplinary and diachronic Study of an ancient aqueduct, Galermi, in the province of Syracuse, and the head of the Network HYDRΩMED. She is also the director of the Maison méditerranéenne des sciences de l'homme at Aix-Marseille Université.

Prof. Dr. Sophie Bouffier
Maison méditerranéenne des sciences de l'homme
BP 647 5, rue du Château de l'Horloge
13094 Aix-en-Provence Cedex 1, France
E-Mail: sophie.bouffier@univ-amu.fr

VINCENT DUMAS

Aix-Marseille Univ, CNRS, Minist Culture & Com, CCJ, Aix-en-Provence, France, is a topographist-archaeologist, specialist of production and analyse of archaeological data, particularly topographical data.

Vincent Dumas
Maison méditerranéenne des sciences de l'homme
BP 647 5, rue du Château de l'Horloge
13904 Aix-en-Provence Cedex 1, France
E-Mail: vdumas@mmsh.univ-aix.fr

PHILIPPE LENHARDT

INRAP, is an architect of the Institut National de Recherches en Archéologie Préventive. He has been the architect of the French mission of Illyrian Apollonia since 1992.

Philippe Lenhardt
Institut d'Art et d'archéologie, Université Paris 1
3 rue Michelet
75006 Paris, France
E-Mail: philippe.lenhardt@univ-paris1.fr

JEAN-LOUIS PAILLET

Aix Marseille Univ, CNRS, Université de Pau, Université Lyon2, IRAA Aix-en-Provence, France, is an architect of the Institut de recherche sur l'Architecture Antique. He is a specialist of ancient Aqueducts, particularly Aqueduct of Nimes-Pont du Gard, and of Barbegal Water Mills.

Jean-Louis Paillet
Maison méditerranéenne des sciences de l'homme
BP 647 5, rue du Château de l'Horloge
13094 Aix-en-Provence Cedex 1, France
E-Mail: jeanlouispaillet14@hotmail.fr