



HAL
open science

Thirsty cities? The supply, management, and perception of water in Byzantine North Africa

Nicolas Lamare

► To cite this version:

Nicolas Lamare. Thirsty cities? The supply, management, and perception of water in Byzantine North Africa. *Journal of Roman Archaeology (JRA)*, 2022, 35 (1), pp.247-279. 10.1017/S1047759421000714 . halshs-03716260

HAL Id: halshs-03716260

<https://shs.hal.science/halshs-03716260>

Submitted on 15 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - ShareAlike 4.0 International License

Thirsty cities? The supply, management, and perception of water in Byzantine North Africa

Nicolas Lamare 

Cluster of Excellence ROOTS, Kiel University <lamare.nicolas@gmail.com>

Abstract: Cities of North Africa experienced a long occupation up to the late 7th c. CE. Despite numerous studies on Late Antique urbanism, no systematic investigation of urban hydraulics has been carried out so far. This paper examines the hydraulic topography of three cities in the Byzantine period (ca. 6th c. CE): Leptis Magna (Tripolitania), Sbeitla (Byzacena), and Timgad (Numidia). This analysis assesses to what extent Late Antique societies managed the cities' water supply by maintaining or transforming preexisting hydraulic networks. It considers the continuity of aqueducts and the reorganization of water networks, the state of hydraulic management and technology, and the perception of water resources. The hydraulic networks inherited from the Early Roman period were to some extent preserved, although greatly adapted to new concerns for security and new technical and environmental constraints, illustrating the resilience of Late Antique societies.

Keywords: Maghreb, Late Antiquity, Byzantine Africa, urban settlement, water supply, hydraulic technology

Despite the long occupation of the cities of North Africa at least until the 7th c. CE, and the notable conservation of their ancient remains, research has mainly focused on the cities of the 4th c. CE, their reconfiguration in the Vandal period (5th c. CE), and the Christianization¹ and militarization² of urban centers in the Byzantine period (6th–7th c. CE). The topic of urban hydraulics in particular has seen little systematic work in the region. Water is an essential resource for permanent settlement and a concern for survival during sieges. However, its availability varies according to geographical and climatic conditions, as well as the technical and financial resources invested in its distribution. Studying water access as a crucial component of urban transformations provides a different perspective on Late Antique African cities.

Water use in Roman cities has been the subject of many studies, especially concerning the Imperial period.³ However, diachronic perspectives have been neglected and studies on water in the Late Antique world have only recently expanded their focus⁴ beyond Rome⁵ and Constantinople.⁶ Some major questions remain to be answered regarding North African cities.⁷ Were aqueducts still functioning in this period? How were fountains and baths maintained? How were urban settlement and water supply reorganized? To what

¹ Gui et al. 1992; Baratte et al. 2014.

² Pringle 1981; Lecat 2014.

³ Among other references concerning the Romans in North Africa, see Wilson 1997; Tomasello 2005; Lamare 2019a with a previous bibliography.

⁴ Pickett 2016; Lamare and Murer 2020; Martínez Jiménez 2020.

⁵ Ward-Perkins 1984, 119–54; Coates-Stephens 1998.

⁶ Crow et al. 2008.

⁷ Cf. Duval 2006, 136, 140, 142, 193.

extent were elements of hydraulic infrastructure intentionally integrated within city walls? The management of such infrastructure is also a concern: how were constructions and restorations carried out, and by whom? How did ancient societies adapt to changes over time and the hazards of climate, from both a local and a Mediterranean perspective? Furthermore, our interpretation of the availability of water resources must be shaped by the lived experience of past societies. How were waterworks perceived in Late Antiquity?

When water in the Late Antique period is studied, hydraulic infrastructure is generally treated in the same way as any other monument: the main focus is on the state of preservation, the use of spolia, the decoration, the inscriptions, or – in the case of bath complexes – the transformations of rooms.⁸ Even if the idea of how water was used in monuments is mentioned, it is rarely related to larger water networks. Yet baths, fountains, and houses were part of a wider system, and even cisterns were dependent on a water supply, whether from rainfall or aqueducts.

This paper assesses the extent to which Late Antique societies managed the water supply of cities by maintaining or transforming preexisting hydraulic networks. It adopts topographical, technical, economic, and cultural perspectives while considering selected case studies of cities with different topographies and occupation phases at least until the end of antiquity. The approach employed here is to establish the “hydraulic topography” of cities⁹ by analyzing the chronological and spatial distribution of the hydraulic infrastructure throughout its phases of operation and abandonment. Using archaeology or epigraphy, this method allows one to identify the latest evidence for the functioning of the water monuments and, when possible, their date of abandonment. This approach makes it possible to determine which urban areas still had a water supply and whether water was provided by an aqueduct or by the collection of water via wells or cisterns. These elements must be considered in relation to the topography of the cities: if data relating to the elevation of the structures is not systematically recorded, the hypsometry of the sites confirms the possibility of gravity flow and the supply to the various locations studied. Moreover, it is worth putting the archaeological data into conversation with the testimonies of literary and legal sources that are much richer for the Eastern Mediterranean but that – with the usual precautions – deserve to be compared with the situation of western cities. The economic and administrative conditions in the provinces and cities changed throughout Late Antiquity, altering the context of urban infrastructure management as well as technical and construction capacities. The sources referring to Justinian’s politics of construction and restoration, especially in the reconquered cities, mention hydraulic structures. Their message is significantly different from that still read in the inscriptions up to the 4th c. CE and testifies to a new conception of urban hydraulics.

In this study, I will draw on recent work carried out on Late Antique cities in North Africa¹⁰ and on the published evidence available for hydraulic infrastructure, supplemented by field observations from Sbeitla, in order to develop a hydraulic topography. My focus is the Byzantine period in North Africa from the early 6th to the late 7th c. CE. For the majority of North Africa, the mid-6th c. corresponds to the Byzantine reconquest by Justinian and is regarded as the beginning of a new political period with a more complex

⁸ Thébert 2003, 415–28.

⁹ Lamare 2019a, 287–91.

¹⁰ Leone 2007; Panzram and Callegarin 2018; on the transition toward the Middle Ages, see Bockmann et al. 2019.

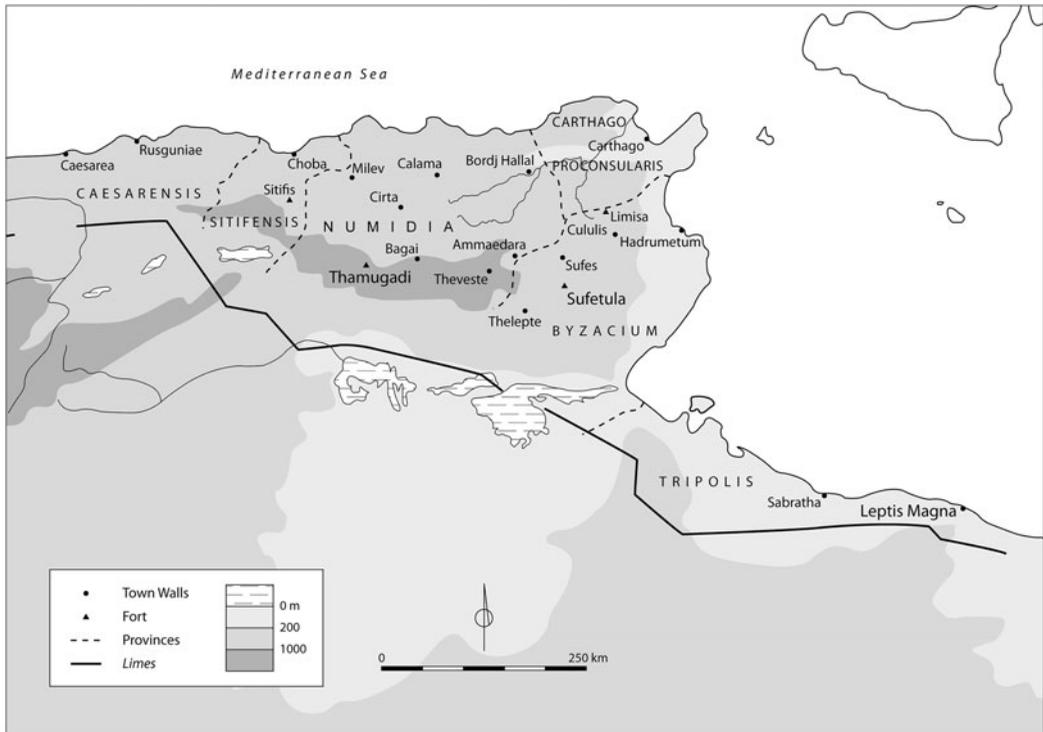


Fig. 1. Map of Byzantine North Africa showing major sites, including those studied in this paper. (After Pringle 1981, map 3.)

security context; cities were considerably transformed in this period and deserve individual, in-depth study.¹¹ For the beginning of Late Antiquity, which corresponds to the 4th and the early 5th c., the context of water has been well studied in North Africa. Baths¹² and fountains¹³ are known to have been restored or newly built, based on both archaeological and epigraphic evidence. However, from the 5th c. onward, inscriptions are very scarce. Most of the inscriptions known after that date are either funerary (Christian) inscriptions or dedications of city walls.¹⁴ Regarding water, there is no epigraphic data from the 5th c. onward.¹⁵

This paper is based on three case studies (Fig. 1): Leptis Magna, a fortified harbor city in Tripolitania; Sbeitla (anc. Sufetula), an inland city of Byzacena with several fortified locations; and Timgad (anc. Thamugadi), a city in Numidia at the foot of the Aures Mountains, which included a fortress at its edge. Each of these cities has a different topography, but all are known to have been occupied at least until the end of antiquity (6th–7th c. CE). All three cities were equipped with an aqueduct in the 2nd c., and several of their water monuments are dated to Late Antiquity. Only by taking a long-term perspective is it possible to understand

¹¹ For a historical account, see Duval 2006, 128–33.

¹² Thébert 2003.

¹³ Lamare 2019a; Lamare 2019b.

¹⁴ Durliat 1981; Pringle 1981.

¹⁵ To my knowledge, the last mention of the construction of a *fons* found at Uzali Sar is dated to 408 (*CIL* VIII 25377 = *AÉpigr* 1908 76); in Thuburbo Maius, the transformation of the Winter Baths is dated between 395 and 408 (*ILAfr* 276 = *AÉpigr* 1914 57). See Lamare 2019a, 241–47.

changes and developments in water management, as well as the resilience capacity of societies.¹⁶ The data, however, are scarce and should be used with caution because of the age of the excavations and a lack of earlier interest in the Late Antique structures. The transformations of baths and fountains are poorly documented, as are those of aqueducts. The objective here is to gather the available data on the Byzantine period and to stimulate reflection on the water supply in Late Antiquity.

Based on these case studies, this paper will address several aspects of water management. First, although Carthage has been investigated,¹⁷ the maintenance of aqueducts and other hydraulic monuments into Late Antiquity needs to be evaluated in other North African cities. Here, we need to think specifically about the elaboration of new strategies and the adaptation of hydraulic infrastructure at the end of antiquity. More broadly, questions concerning the relationship between urban settlement and access to water need to be considered, particularly in the context of fortifications. Second, this relationship is also associated with the continuity of city administration and management, the economic capacity of communities, and the technical knowledge and availability of skilled workers – all of which need to be assessed. Third, few questions have been raised concerning the perception of water-related monuments during this period. Although the representation of the city is a quite well-studied topic,¹⁸ in Late Antique texts and inscriptions, mentions of the restoration of infrastructure and the construction of fortifications could be both rhetorical formulas and reflections of ancient realities, as the archaeological remains demonstrate. This paper argues that the hydraulic networks inherited from the Early Roman period were in some cases preserved while at the same time greatly modified or adapted to new uses and new security, technical, and environmental constraints, thereby illustrating the resilience of Late Antique societies.

Leptis Magna: flooding, an enclosing wall, and the reorganization of water access

The Wadi Lebda, which flows through Leptis Magna, is dry for part of the year and there is no spring near the town. Until the 2nd c. CE, the inhabitants used only private wells and cisterns, as well as a group of reservoirs near the wadi.

In 119–20 CE, the euergetes Q. Servilius Candidus provided the city with water by way of an aqueduct built at his own expense.¹⁹ The spring of this aqueduct has been identified at the Wadi Caàm, 19 km away, and two pipes leading to Zliten have been identified on the western bank of the river.²⁰ The aqueduct's channel ended in the northern cistern alongside the Wadi Lebda (Fig. 2).²¹ A second cistern was located 150 m further south.²² Originally independent, these two cisterns were later connected by an aqueduct that then crossed the river on a bridge and ran along the left bank. The construction of Candidus' aqueduct was made possible by the erection of a dam across the Wadi Lebda, which directed the water toward the Wadi Rsaf to the northwest. The

¹⁶ Cf. Lichtenberger and Raja 2019.

¹⁷ Wilson 1998, 93–98.

¹⁸ Brogiolo and Ward-Perkins 1999; Loseby 2009, 148–49.

¹⁹ *IRT* 357, 358, 359.

²⁰ Crova 1967, 111–12.

²¹ Romanelli 1925, 215–16, fig. 3.

²² Romanelli 1925, 216–17, figs. 4–5.

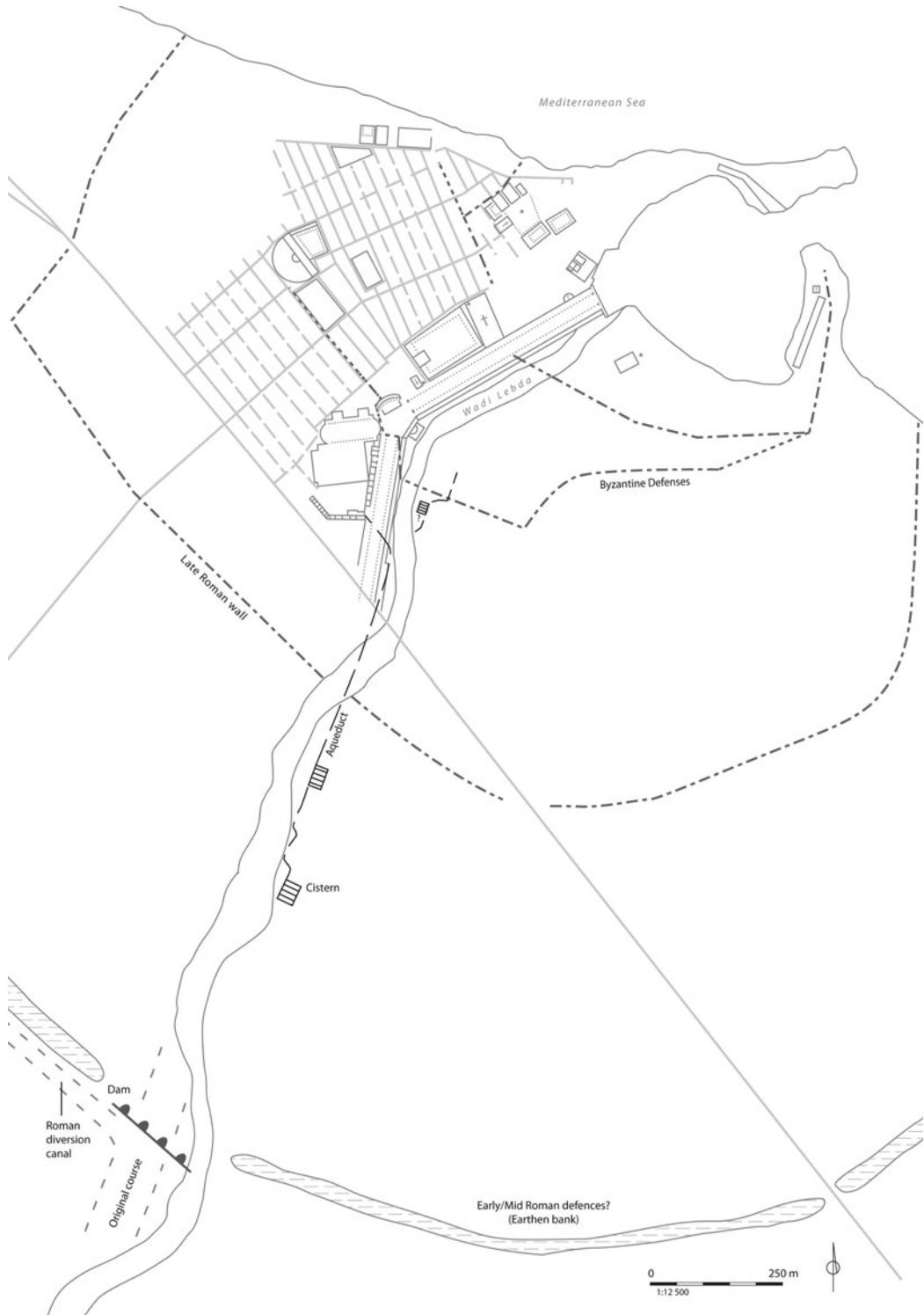


Fig. 2. Plan of Leptis Magna and its surroundings in Late Antiquity. (After Mattingly 1995, fig. 6.1.)

city end of the aqueduct route is not known, but it probably reached the cisterns located near the Baths of Hadrian (Fig. 3). Another stretch of aqueduct was located farther north on the right bank of the Lebda: it could correspond to a diversion of the aqueduct from

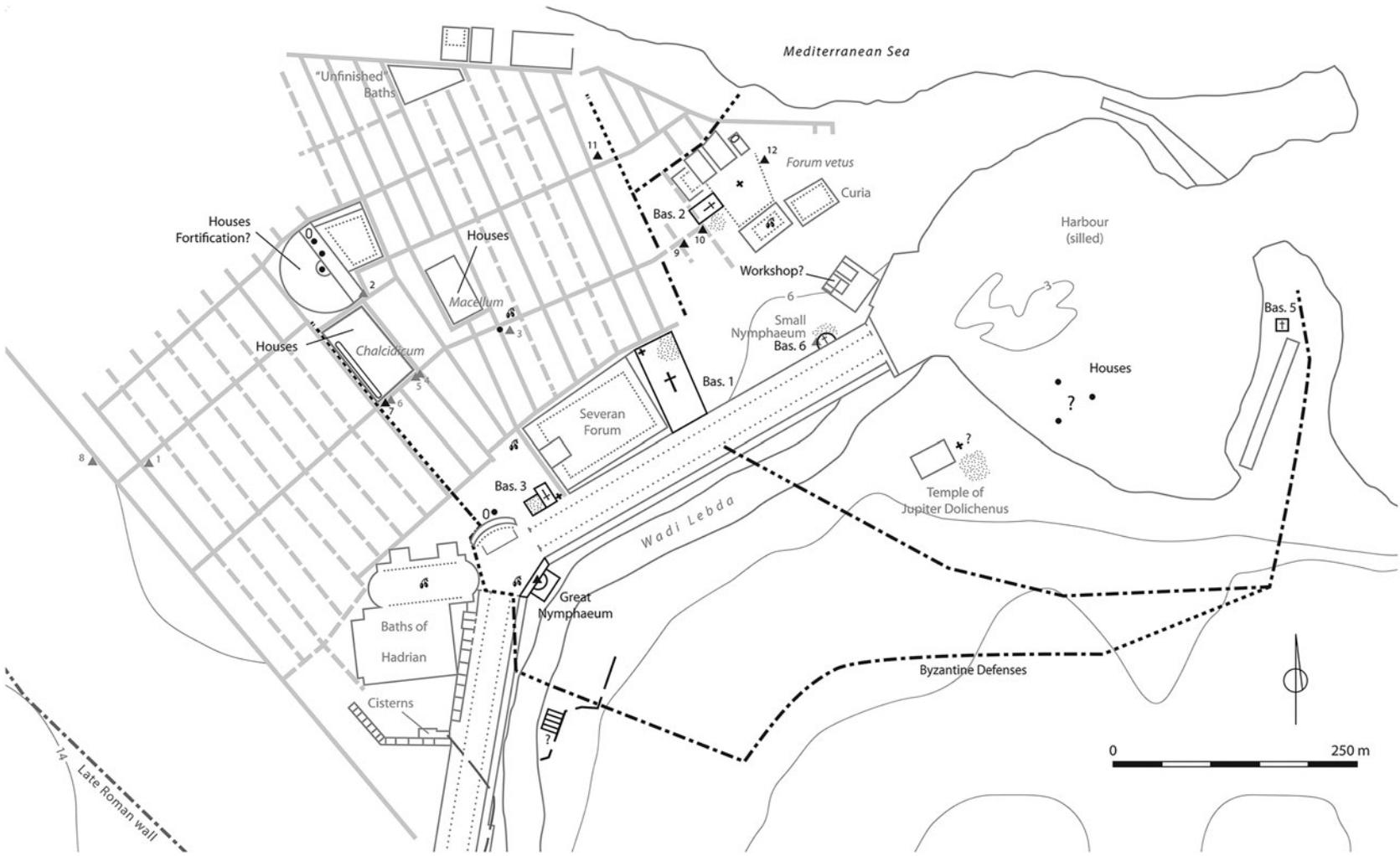


Fig. 3. Plan of Leptis Magna in the Byzantine period. Fountain numbers refer to Tomasello 2005. (After Di Vita et al. 1998, 51, and Mattingly 1995, fig. 6.1.)

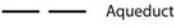
	Public monument / not in use in the Byzantine period		Byzantine necropolis		Oil-press
	Ancient street		Cathedral		Fountain / not in use in the Byzantine period
	Reconstructed street		Basilica		Cistern
	Known wall		Chapel		Well
	Unfinished or dismantled wall		Baptistery		Aqueduct

Fig. 3. *Continued.*



Fig. 4. *Leptis Magna, the cistern of the Chalcidicum, looking north. (Courtesy Jorge Tutor.)*

the northern cistern to supply the city's eastern districts. Perhaps it should be identified together with a potential cistern, a quadrangle with dimensions similar to those of the two cisterns near the wadi farther to the south, visible on the right bank on the topographical surveys of the beginning of the 20th c. at the level of the Baths of Hadrian on the left bank.²³

From these cisterns, I would suggest that two supply branches supplied the city center (Fig. 3). One headed toward the theater and supplied the palaestra of the Baths of Hadrian, the West

Nymphaeum of the Chalcidicum (7), and the Lacus of the theater (2). The other passed through the latrina, which was later transformed into the Nymphaeum of Hercules (3), supplied the Augustan market, and ended its journey in the baths that preceded the "unfinished baths" near the coastline.²⁴ Some other fountains are known and could date from the same time as the building of the aqueduct.²⁵

The Severan period was characterized by a large-scale, planned construction project initiated by Septimius Severus, a native of the city. In addition to the Great Nymphaeum and the Small Nymphaeum, built along the Via Colonnata (Fig. 3), additional fountains were built or restored in the 3rd c. though others ceased to function. The network that had been set up in the previous century was therefore still intended to ensure the supply of water to most of the city. The construction of the cistern in the Chalcidicum portico (Fig. 4), dated to the 3rd c. CE, presumably benefited from the aqueduct that passed through this area; the cistern would have played the role of a castellum for the district.²⁶ The Great Nymphaeum could have been fed via two large cisterns added at that time to the series

²³ Paulin 2015, 153.

²⁴ Tomasello 2005, 186–89.

²⁵ In particular, the fountain (1) on the plaza southwest of the theater (Tomasello 2005, 36) and the Nymphaeum of the Lion (4) next to the Chalcidicum (Tomasello 2005, 120).

²⁶ Tomasello 2005, 187; Pentiricci 2010, 112–15. Di Vita had assigned the construction to the 4th c., after the destruction of the aqueduct then associated with the earthquakes.

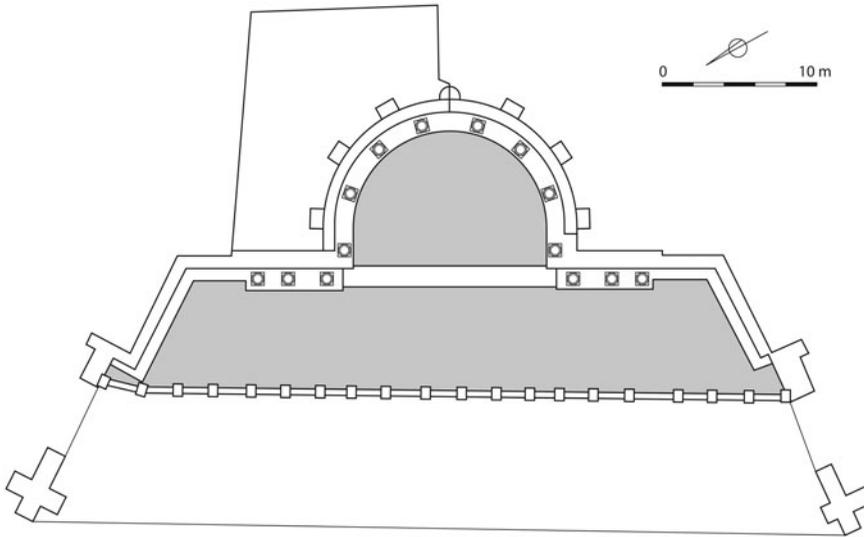


Fig. 5. *Leptis Magna: plan of the Great Nymphaeum. The semicircular basin and the platform turned into a basin are highlighted. (After Ward-Perkins 1993, fig. 40, and Pucci et al. 2011, fig. 2.)*

located near the Baths of Hadrian.²⁷ The channel of the aqueduct identified on the right bank could have fed a Severan construction identified with the baths located behind the temple of Jupiter Dolichenus, baths which may later have been restored by Justinian.²⁸

The city was long considered to have been affected by earthquakes during the course of the 4th c. CE but recent research has shown that the earthquake of 365, in particular, did not impact the city.²⁹ In fact, the interruption of the aqueduct, for a long time attributed to these events, occurred a bit later. It must be ascribed to a break in the dike that enabled the Wadi Lebda to resume its course: this damaged the aqueduct and alluvium invaded part of the Via Colonnata and the Baths of Hadrian; the harbor and the nearby Eastern Baths; the theater and its porticus; the Serapeum (Figs. 3 and 11), and the Forum Vetus.³⁰ The oldest flood deposit has been radiocarbon dated to 320–440 CE,³¹ but the chronological span can be reduced to the years 355–440 because the Baths of Hadrian were still functioning from ca. 355–61, when they were restored.³² After the pipeline was broken by the flow of the wadi, the cisterns of the Baths of Hadrian stopped receiving water, interrupting the supply to the rest of the city. An important modification of the Great Nymphaeum was the transformation of the trapezoidal platform into a basin (Fig. 5). This layout could date to the 4th–5th c., when the water supply stopped, but it is also not impossible to attribute it to the Byzantine period.³³

²⁷ Romanelli 1925, 142–44; Sandoz 2006, 404.

²⁸ Goodchild and Ward-Perkins 1953, 64; Proc., *Aed.* 6.4.3.

²⁹ Pucci et al. 2011, 183 and passim. Among the water monuments, stratigraphic excavations place the destruction of the Nymphaeum of Hercules in the middle of the 4th c., which may have been caused by the earthquake of 365 (Tomasello 2005, 80–81).

³⁰ Pentiricci 2010, 170.

³¹ Pucci et al. 2011, 175.

³² *IRT* 580, *IRT* 653; Pentiricci 2010, 143–45.

³³ Sandoz 2004, 1792–800; Sandoz 2006, 405–7.

The situation changed considerably during the Byzantine period, in terms of both urban occupation and water supply (Fig. 3). The alluvial deposits carried by the Wadi Lebda flooded many streets and squares, as can be seen from the Byzantine-era structures built on these levels.³⁴ Procopius attests to the silting up of the city by the time Justinian's troops arrived and also alludes to the city's desertion by its inhabitants following a first invasion by the Lawatan Berber tribe between 527 and 533 CE.³⁵ This raises the question of whether the street network was preserved. Although no longer used to the same degree as during the Imperial period, its grid pattern might still have been visible.³⁶ A wall was built during the reign of Justinian that reduced the city to a small area near the shore from the old eastern mole to the Severan basilica and up to the temples of the Forum Vetus. A wall enclosing a larger area remained unfinished, leading from the mole toward the Great Nymphaeum and the Chalcidicum.³⁷ Near the Christian basilicas, several of which dated back to the 6th c., oil presses were installed in urban space and tombs are attested within the walls, mainly near places of worship.³⁸ Settlement did not stop, given that dwellings also developed around the craft and religious facilities, creating apparent clusters of activity both inside and outside the city walls.³⁹ Tripolitania, though, seems to have experienced a major change in living standards earlier than other parts of North Africa.⁴⁰

Wells and cisterns are documented within these settlement areas, and these provided for the water needs of the population. Several wells have been identified in the harbor area of Leptis Magna close to the eastern mole – filled with ceramics dated from the late 5th CE to the third quarter of the 7th c. CE⁴¹ – and in the theater.⁴² Whereas one well was located behind the great Severan exedra, which was possibly settled in Late Antiquity,⁴³ another was dug at the corner of the streets facing the Nymphaeum of Hercules (Fig. 3.3), probably after its abandonment.⁴⁴ In addition, three cisterns are recorded: one in the theater, which may have housed not only inhabitants but also soldiers,⁴⁵ one behind the great exedra,⁴⁶ and one in the podium of the Temple of Hercules-Melqart on the Forum Vetus.⁴⁷

Two fountains in the Forum Vetus may also date to Late Antiquity or even to the Byzantine period (Fig. 3). One (10) is located along the street near the Basilica (2) and is thought to be a Byzantine construction based on the use of murex in its mortar.⁴⁸ The

³⁴ Approximately 50 cm: Goodchild and Ward-Perkins 1953, 53; cf. Pentiricci 2010, 142.

³⁵ Proc., *Aed.* 6.4.1–6.

³⁶ Cf. Sbeitla, below.

³⁷ Goodchild and Ward-Perkins 1953.

³⁸ Leone 2007, 185–87.

³⁹ Munzi 2010, 73–75.

⁴⁰ Mattingly 1995, 183–85, 215–16.

⁴¹ Laronde 1994, 995; Pentiricci 2010, 158–59.

⁴² The well in the orchestra is Late Antique and may be post-Byzantine. The others in the stage building were filled with fragments of inscriptions and sculptures from the theater and sherds of ARS: Caputo 1987, 57 n. 7, 124–25; Pentiricci 2010, 119.

⁴³ Pentiricci 2010, 142.

⁴⁴ Tomasello 2005, 80.

⁴⁵ Munzi et al. 2003; Pentiricci 2010, 119, n. 140.

⁴⁶ Pentiricci 2010, 142.

⁴⁷ Ricciardi 2005, 330.

⁴⁸ Tomasello 2005, 14.

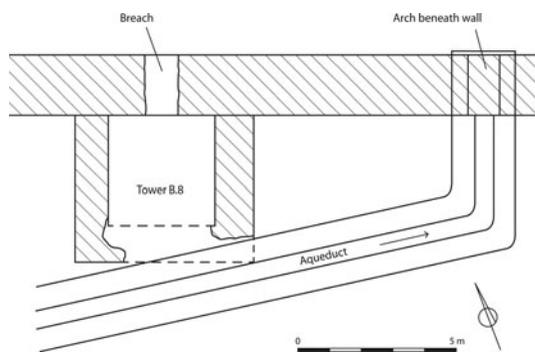


Fig. 6. *Leptis Magna*: passage of an aqueduct under the Byzantine walls next to tower B.8. (After Goodchild and Ward-Perkins 1953, 63.)

dated to the Byzantine period because of the use of murex. This nymphaeum was fed from the rear reservoir via the Chalcidicum cistern.⁵² Francesco Tomasello has suggested that the pipe supplying this area of the city was still working and was protected by the southern Byzantine wall that would have followed the street linking the plaza of the Great Nymphaeum to the theater.⁵³ However, at least on the left bank of the wadi, it is difficult to reconstruct a supply from the aqueduct considered to have been destroyed by the floods. In this case, the nymphaeum of the Chalcidicum no longer operated as a fountain pouring out a continuous stream of water, but, fed by a rainwater collection cistern, it had to either let water run from an overflow or deliver it through a tap. In any case, dating structures to the Byzantine period by the use of crushed murex is not reliable: the technique, long identified in the fortifications,⁵⁴ has also been identified in the latrines located behind the Baths of Hadrian, dated to the 2nd–3rd c. CE.⁵⁵ Archaeological observations seem insufficient and only archaeometric analyses will provide answers to this question.

The state of preservation of the Great Nymphaeum in the Byzantine period is poorly understood. The monument was included in the initial planning of the Byzantine wall, no doubt because it could have played the role of a tower. The destruction of half the structure, however, could be attributed to the flooding of the wadi in the 6th c. CE,⁵⁶ or earlier. If the nymphaeum was no longer supplied by the aqueduct via the Baths of Hadrian's cisterns, then its two basins played the role of rainwater storage – a kind of improvised cistern.⁵⁷

⁴⁹ Tomasello 2005, 188 and n. 455.

⁵⁰ Tomasello 2005, 15, 188 and n. 455.

⁵¹ Three other fountains reported by Tomasello (2005, 14–15) without dating or a corresponding bibliography are distributed in different parts of the city: one in the southwest, on the north side of street (8); the second near the Byzantine gate, inside the fortification (9); the third in regio V, near the Serapeum (11).

⁵² Tomasello 2005, 150–51.

⁵³ Tomasello 2005, 188.

⁵⁴ Goodchild and Ward-Perkins 1953, 55.

⁵⁵ Wilson 2002, 255.

⁵⁶ Sandoz 2004, 1797.

⁵⁷ Sandoz 2006, 406–7.

However, an aqueduct may have supplied water until a later period in time. In the 1950s, excavations of the southern Byzantine wall on the right bank of Wadi Lebda uncovered the conduit of an aqueduct at the bottom of tower B.8, which ran through an arch in the wall (Fig. 6).⁵⁸ This feature presupposes that the aqueduct was working and was still delivering water when the wall was built, or at least that it had been restored shortly after the Byzantine reconquest.⁵⁹ The origin of this aqueduct, however, raises several questions. This branch could be identified with the one that ran along the right bank of the wadi. Either it was associated with the two large cisterns that received water from the Wadi Caàm – although these were largely silted up at the beginning of the 6th c. – or it was connected to the third possible cistern on the right bank, still functional and fed by the same aqueduct of the Wadi Caàm. The destination of this branch is not known. It could have served the eastern districts of the city, and although it has not been excavated, it was possibly built as early as the Antonine period, when the Wadi Lebda was channeled. It could have supplied a Severan bath rebuilt by Justinian, as mentioned before.

Sbeitla: scattered fortifications, a pipe network, and the remodeled distribution of the water supply

Sbeitla is known for its Late Antique phases as a result of the important studies on the Christian basilicas.⁶⁰ An aqueduct is identified coming from the north of the city, probably supplied by the spring of the Wadi Sbeitla (Fig. 7). An inscription reused in the aqueduct-bridge provides a terminus post quem for its construction in the mid-2nd c. CE.⁶¹ A few branches of water pipes, attributable to the period of the aqueduct's construction, have been identified in the central part of the city.⁶² A large part of the hydraulic network may have been modified in the course of the 4th c., at a time when the city was evolving.⁶³ The latest epigraphic information about water monuments concerns the construction of at least one⁶⁴ and possibly three – monumental fountains,⁶⁵ and the restoration of the Great Baths in the late 4th c.⁶⁶

Around the 5th c. CE,⁶⁷ the so-called Édifice des Saisons – a rich house where a mosaic is dated to the early 5th c. – was decorated with two nymphaea. Concerning the bath complexes,⁶⁸ the baths (10) attached to the Basilica (2) are thought to have been built in the early 5th c.,⁶⁹ and the small baths (26), which were probably private, present a mosaic dated to the 5th–6th c.⁷⁰ The baths (10) had a cistern, the dimensions of

⁵⁸ Goodchild and Ward-Perkins 1953, 62–63, fig. 8a.

⁵⁹ Goodchild and Ward-Perkins 1953, 72–73.

⁶⁰ Duval 1971a with a comprehensive bibliography; see also Baratte et al. 2014.

⁶¹ *CIL* VIII 229 = 11320 = *ILS* 354 = *ILPSbeitla* 14 dated 145–47.

⁶² State of research in Bejaoui 2018; but see now Lamare 2019a, 367–69.

⁶³ Lamare 2017, 102–6.

⁶⁴ The fountain southwest of the forum, dated 364–67: *CIL* VIII 234 = 11329 = *AÉpigr* 1958 158 = *ILPSbeitla* 84. See Cèbe 1957.

⁶⁵ Lamare 2019a, 369–72, nos. 41–3.

⁶⁶ *AÉpigr* 1921 30 = *IL Afr* 141 = *ILPSbeitla* 81; *ILPSbeitla* 33.

⁶⁷ Discussion and further bibliography in Lamare 2017, 108–9.

⁶⁸ Cf. Maréchal 2020, 158–63.

⁶⁹ Duval 1971a, 304–9; Thébert 2003, 157–59.

⁷⁰ Thébert 2003, 157.



Fig. 7. Plan of Sbeitla in the Byzantine period. (After Duval 1982, fig. 10, and Lamare 2017, fig. 16.)

which, however, make it unlikely that it could have been supplied solely by rainwater collection.⁷¹ In contrast, neither the small baths (26) nor the Édifice des Saisons had a

⁷¹ 5.50 × 3.50 m according to Duval 1971a, plan on leaflet VIII. The surviving height is not indicated.



Fig. 8. Sbeitla: holes in the balustrade of the northern fountain. (Lamare 2017, fig. 15.)

storage device. In all three cases, it is therefore necessary to assume an external supply of running water.⁷²

Among the water monuments of Late Antiquity, the northern fountain, the construction of which is supposed to have taken place in the middle of the 4th c. CE (as is the case with two other, rather similar, fountains in the city), deserves special mention. Its original design may have included a second basin, which has now disappeared. The existence of the second basin is suggested from the model of the other fountains on the site and on the basis of a study of the pre-

preserved basin and the reworking of the pavement of the courtyard.⁷³ In a later phase, which could have been as early as the 5th c., this second basin may have been torn out, and the remaining basin transformed into a distribution basin. The holes drilled into one of its balusters could have accommodated pipes that redistributed the water to different sectors of the city (Fig. 8).⁷⁴

The urban situation seems quite stable until the Byzantine conquest, but important changes occurred in the late 6th c. CE (Fig. 7).⁷⁵ Noël Duval has suggested that streets were filled, blocking the Early Roman grid at least around the *domus ecclesiae* (Basilicas 1 and 2) and the southeast district, where oil presses were located. Although changes of level are attested in some places and could be related to the filling of streets (Fig. 9), research on this subject will have to be further pursued in the preserved areas given that most of the streets were completely cleared at the beginning of the 20th c. without any concern for stratigraphy. Another major modification is the construction of fortifications that are, unfortunately, undated but are heterogeneous in their building techniques: the amphitheater, the northern temple, and the forum were fortified, and “fortified houses” were built.⁷⁶ The city was still inhabited. Duval assumes there were clusters of settled activity around fortifications or fortlets and churches, sometimes associated with oil presses. However, this image of the city is very incomplete and only reflects the excavated areas.⁷⁷

In the two southeastern fortified houses, wells that enabled the occupants to be relatively self-sufficient are attested. The northernmost fortified house also had at least one cistern, whereas two adjacent rooms coated with tile mortar could have been used

⁷² No remains of a large public cistern are present at the site. Only the large cistern can be mentioned, but the possibility of a covered space seems to have been long since refuted.

⁷³ Lamare 2017, 99–102.

⁷⁴ Lamare 2017, 107–9; examples are attested in Asia Minor: Jacobs and Richard 2012, 43–53.

⁷⁵ Duval 1982, 619–26.

⁷⁶ Lecat 2014, I, 332; II, 303–15.

⁷⁷ See the discussion in Leone 2007, 181–85.



Fig. 9. Sbeitla: raising of the threshold testifying to the elevation of the street level. The upper parts of the wall are restored. (N. Lamare, 2019.)

for water storage.⁷⁸ The baths (26) may still have been in use. In the *domus ecclesiae*, works are attested until the 7th c. CE,⁷⁹ which raises the question of the functioning of the baths. To the northwest, the *Édifice des Saisons* and the adjacent house may still have been in use as part of a cluster built near the fortifications of the amphitheater and the old temple. However, the fountain to the southwest of the forum may possibly have been converted into a dwelling during this period.⁸⁰

The inventory of these hydraulic structures implies the presence of water but due to the lack of excavations we cannot assess the extent to which a large-scale distribution network might have supplied the different areas of the settlement. Was the aqueduct still in use? There are no archaeological or epigraphic data to answer this question. However, these water monuments would not have been able to operate without a perennial water supply in the city.⁸¹ It should be noted that our lack of knowledge about the housing situation throughout the history of the city makes it impossible to identify any wells or cisterns that might have complemented or even replaced a water supply system. To the northeast of the forum, the discovery of a modest basin that cannot be dated and, above all, of a box with three openings that housed lead pipes⁸² – the bottom of which is composed of a reused Byzantine epitaph⁸³ – indicates that a system of water distribution under pressure continued at the end of the Byzantine period and even into the beginning of the

⁷⁸ Lecat 2014, I, 303–6; II, 306–8.

⁷⁹ Duval 1971a, 85–88: the last identifiable phase of transformation in the Basilica (1) is posterior to its remodeling, which dates to the end of the 6th c.

⁸⁰ Cèbe 1957, 166.

⁸¹ Lamare 2017, 109–11.

⁸² On these junction boxes, see Hodge 2002, 317–20.

⁸³ Bejaoui 1996, 43 and fig. 17.

Arab-Muslim period.⁸⁴ As for the urban context, although our knowledge is limited, we can see that the mastery of hydraulic techniques was also pursued during a later time period. It is therefore possible to consider the continuity of water distribution, but through networks different from those of the Early Roman Empire.

Timgad: a water spring, a garrison, and the local security issue

At Timgad, numerous wells were dug as soon as the colony was established at the end of the 1st c. CE, which would have provided most of the water needs of private houses. The wealthiest households were provided with wells wherever the water table was present. The first supply works were carried out in 146.⁸⁵ At this time, the Ain Morri spring was tapped and transported to the city by a south–north pipeline, a work that was completed in 174.⁸⁶ The Ain Morri spring was supplemented by drainage water from the Aqua Paludensis ca. 183–85.⁸⁷ In the 2nd c., a spring sanctuary was built to the south of the city (Fig. 10). Numerous alterations were carried out during the Severan period.⁸⁸ A large basin whose water supply was provided by a brick canal on the south wall was located in the center of the spring sanctuary. Pipes coming from the southeast and the southwest have been identified around the sanctuary. Water then passed from the basin through a viridarium and continued further north.⁸⁹

No specific information is available on the city's water supply in the 4th c. CE. The latest evidence concerns the baths, which were particularly numerous in the Roman period in this small city.⁹⁰ The baths (5) of the Donatist Cathedral were part of an ensemble dating back to the late 4th–early 5th c., with possible modifications during the Byzantine period.⁹¹ In the North Small Baths (1)⁹² and the South Great Baths (3),⁹³ mosaics were restored from around the 5th to 6th c. according to stylistic evidence. The encroachment of the North-East Small Baths (2) on the street indicates a relatively late dating and implies the disuse of the city wall that cannot be earlier than the Severan period. The Byzantine style of several capitals would also indicate a late date, or at least a long period of use.⁹⁴ Despite the lack of data, mosaic restorations with terracotta similar to the pilae tiles of the hypocaust stacks could indicate a rather late use of the South Small Baths (4), which are also very close to the Byzantine fortress.⁹⁵ The water supply for these baths is not known, but no cistern has been identified in the studies that have been completed thus far. The supply would

⁸⁴ The use of lead pipes is a good indicator of the existence of a pressurized water supply, because pipes made of other materials were less resistant to pressure. On lead pipes and pressurized systems, see Hodge 2002, 232–38; 307–15.

⁸⁵ *AÉpigr* 1985 875a. On water supply in the city, see Thébert 2003, 228–9; Schmölder-Veit 2009, 138–41; Lamare 2019a, 333.

⁸⁶ *CIL* VIII 17869; it is identified with the water supply called *aqua[m] ---[netensem]*.

⁸⁷ *AÉpigr* 1934 40.

⁸⁸ *CIL* VIII 2369; on the sanctuary, see Lassus 1981, 49–51; Laporte 2018.

⁸⁹ Laporte 2018, 198.

⁹⁰ Cf. Maréchal 2020, 145–50.

⁹¹ Thébert 2003, 252–53.

⁹² Thébert 2003, 229–30.

⁹³ Thébert 2003, 240–42.

⁹⁴ Thébert 2003, 234–35.

⁹⁵ Thébert 2003, 242–43.

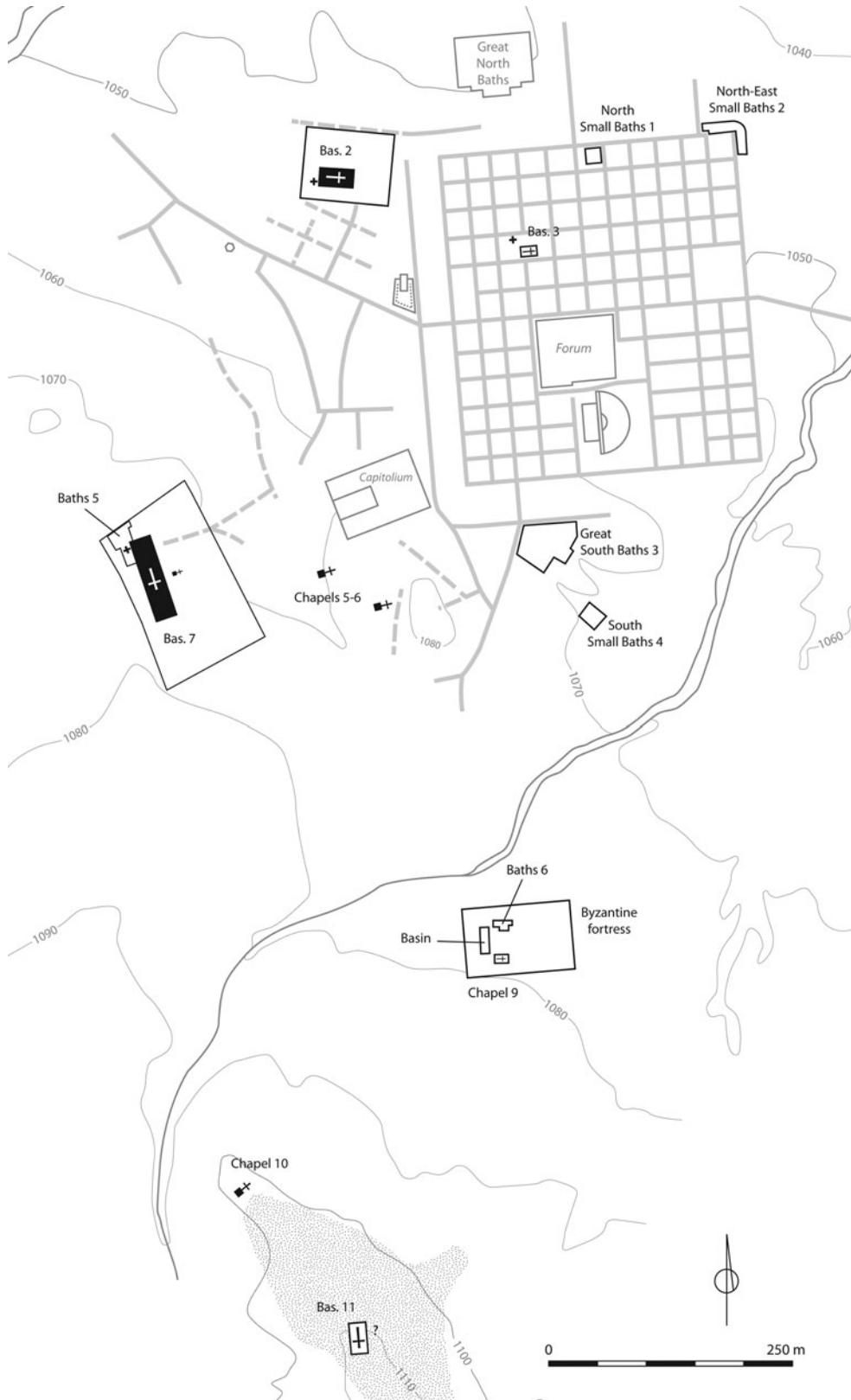


Fig. 10. Plan of Timgad in the Byzantine period. (After Courtois 1951, inset pl.)

have remained very dependent on the highly developed water supply network in the city of the Early Roman period,⁹⁶ and it must be assumed that it still functioned, at least partially, until quite a late date.

Construction or restoration activities can therefore be identified up to the 5th c. CE, and sometimes, up to the 6th c. (Fig. 10). The Christian buildings confirm the continuity of the city's life in the Byzantine period. These include the chapel of the Byzantine fortress (9) with its basin,⁹⁷ the Donatist cathedral (7) with its fountain supplied by a pipe coming from the southern part of the courtyard,⁹⁸ possibly the Catholic cathedral (2),⁹⁹ the two chapels (5–6) near the Capitol,¹⁰⁰ and the Basilica (3) of Januarius in the city center.¹⁰¹ The chapel (10) of Gregory the Patrician, built by John of Tigisi between 641 and 647, is the latest construction attested in the city.¹⁰² There is no evidence that Timgad, in contrast to what Procopius indicates, was “emptied of its population by the Moors and razed to the ground”¹⁰³ in 484. The inscription mentioning the reconstruction of the town referred primarily to the fortress.¹⁰⁴

In fact, an interesting and important feature of the hydraulic infrastructure of the Byzantine period is the reuse of the Aqua Septimiana pool to the south of the city (Fig. 10). The period between 214 CE and the inauguration of the fortress in 539–40 CE¹⁰⁵ is not really known. But at that time, the sanctuary was destroyed, and the basin was enclosed in the new Byzantine fortress. The choice of the site was certainly influenced by the presence of water. Jean Lassus indicates that walls built on the sides of the original basin were intended to increase the storage capacity of this tank. He observes, however, that the well-preserved overflow on the north face, which still fed structures outside the fortress, appears to contradict his interpretation (Fig. 11).¹⁰⁶ In any case, it must be noted that the remodeling carried out on the basin and the hydraulic installations that benefited from its supply attest to the availability of water and therefore to the functioning of the supply from the spring catchment.

Among the other water structures of the fortress (Fig. 12), a basin was situated next to the north gate, which was approximately 4 m deep and kept partly above ground and partly below. No supply or discharge openings have been identified on this basin. Rainwater could have been collected from the roofs, or water might have flowed from the nearby baths, because pipes have been identified in the street in between.¹⁰⁷ The fortress, in fact, included small baths (6)¹⁰⁸ consisting of eight rooms and five fairly small

⁹⁶ Lohmann 1978, 168, fig. 1.

⁹⁷ Gui et al. 1992, 280–82, no. 9.

⁹⁸ Ballu 1914, 325; Gui et al. 1992, 274–79, nos. 7–8.

⁹⁹ Gui et al. 1992, 265–67, no. 2.

¹⁰⁰ Gui et al. 1992, 271–74, nos. 5–6.

¹⁰¹ Gui et al. 1992, 267–70, no. 3.

¹⁰² *CIL* VIII 2389 = 17822 = *ILS* 839 = *ILCV* 1832; Lassus 1981, 15–16; Gui et al. 1992, 282–84, no. 11.

¹⁰³ *Proc.*, *Vand.* 2.13.26 (trans. Dewing 1916, 321).

¹⁰⁴ Lassus 1981, 14–15; Modéran 2003, 384; cf. *infra*.

¹⁰⁵ Durliat 1981, 47–53, nos. 19–21.

¹⁰⁶ Lassus 1981, 110–16.

¹⁰⁷ Lassus 1981, 105–6.

¹⁰⁸ Lassus 1981, 127–46.



Fig. 11. Timgad, basin of the Byzantine fortress viewed toward the north. Note the overflow indicated by an arrow. (Xiaotong Gao, 2015, CC BY-SA 3.0.)

basins. The water supply for these baths has not been identified, although the idea of a supply from the nearby spring basin is briefly mentioned by Lassus.¹⁰⁹ No other possibility for the filling of the baths can be suggested: no cistern is identified in these baths, except for the aforementioned reservoir located near the gate of the fortress, which would have benefited from the water supply of the spring via the baths. Despite the small volume of the basins, manual filling seems to be excluded, especially given that access to the baths was from the east, opposite the spring basin.

North of the fortress, at the location of the former sanctuary, lead pipes fed two reused sarcophagi from the spring basin.¹¹⁰ The sarcophagi served as fountain basins. The fountains may have been built before the 6th c. CE and were only refurbished in the time of Justinian.¹¹¹ The restoration of the fountains in Byzantine times fits well with that of the basin at the same period.

What role did the sanctuary pool play in supplying the city? The pipes seem to continue northward toward the southern baths, but data are scarce. However, it should be remembered that Roman baths were discovered under the viridarium of the Severan sanctuary.¹¹² It is likely that the spring water was collected and used at that time in this area. Perhaps it

¹⁰⁹ Lassus 1981, 106.

¹¹⁰ Lassus 1981, 115–16.

¹¹¹ Lassus 1981, 220–23: The water inlet and outlet pipes, the access staircase, and the wall against which the slab rests appear older. The fountain, moreover, was obviously connected with the small earlier baths. It could have remained operational at the time when the Late Antique building was in use.

¹¹² Lassus 1981, 219–20.

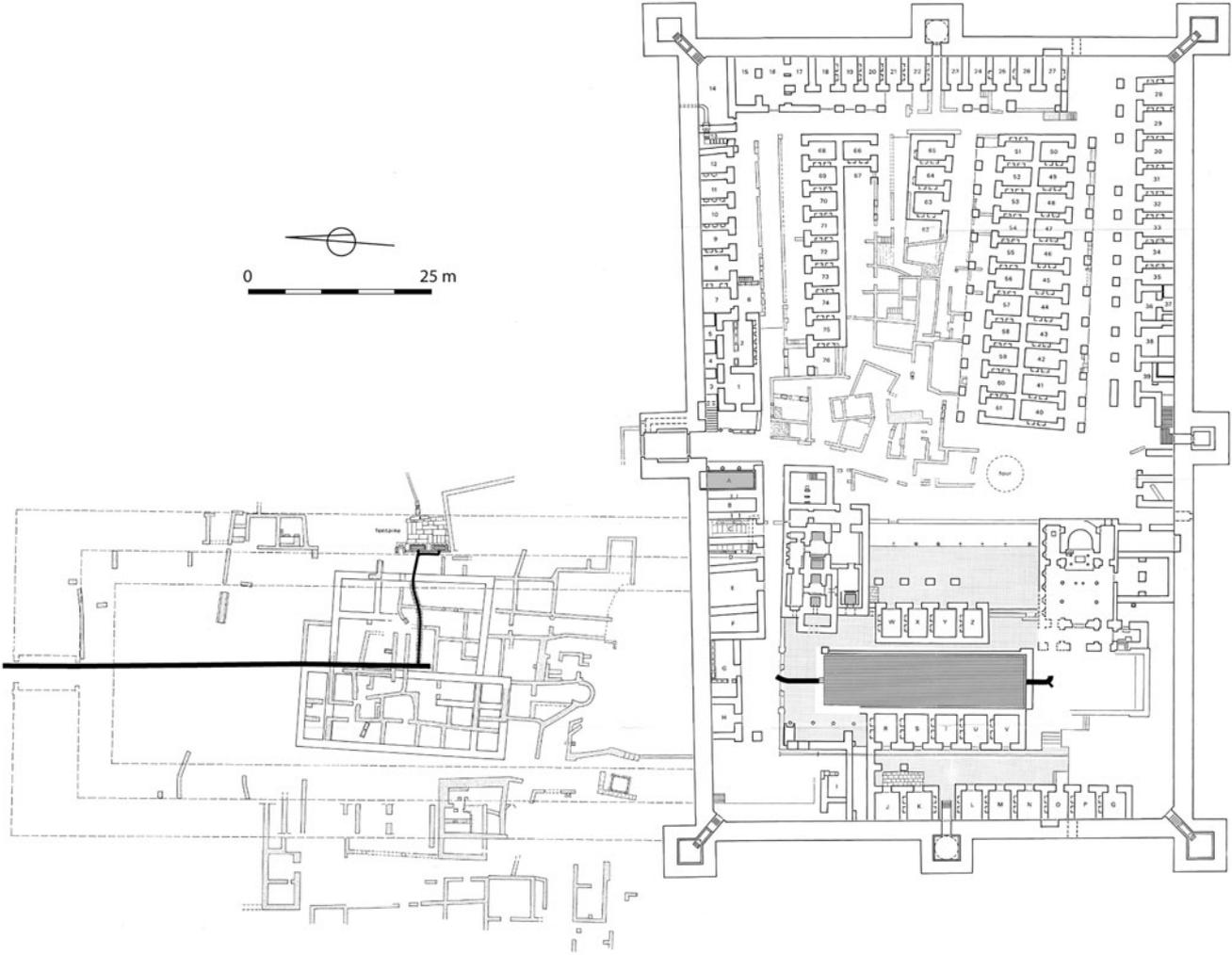


Fig. 12. Plan of the Byzantine fortress of Timgad. Hydraulic structures are highlighted. (Lassus 1981, inset pl.)

was also used to supply the southern part of the city, whereas the Ain Morri supplied the theater area and the northeastern quarters.

The fortress, probably settled in the first place because of the perennial spring and the basin, may also have attracted urban occupation during the Byzantine period. In fact, most of the churches attested in this period are located southwest of the original city and even south of the fortress, as are three of the baths (3, 4, 6) active in the Byzantine period (Fig. 10). The area between the city and the fortress has not been excavated, but it seems clear that it was occupied. Furthermore, the structures to the north of the fortress, which must be attributed to the Byzantine period, indicate that the population sought the protection of the fortress when it was still occupied by a garrison or when it became a protective environment for a village.¹¹³

Of course, the evidence for churches and fortifications, largely overexploited in the study of Byzantine urban topography, cannot be used to conclude that the urban center had been moved. Although the housing is not well known in its latest phases, two baths may still have been active in the early town center, and the numerous wells could have provided access to the water necessary for domestic use. In the city center,¹¹⁴ the presence of stables, some of which may be dated to the Byzantine period, is another testimony to the continuity of settlement in this area. However, the mention of the destruction of the town in 484 CE, even if exaggerated, hints at the possible abandonment of part of the primitive urban center. This is suggested by the reuse of the forum pavement¹¹⁵ and by a privileged settlement in the south around the fortress and its spring that provided protection and subsistence.

Where was the water? Continuity and reorganization of hydraulic networks

In the cases studied here, the archaeological data alone allow us to identify several scenarios for hydraulic networks in the Byzantine period by identifying which monuments considered to be heavy water consumers were still in use at that time.¹¹⁶ The absence of cisterns in baths implies an external supply, via an urban supply network, as in the case of several baths in Timgad. In any case, when a small cistern existed – for example, in the baths of the Basilica (2) in Sbeitla – the collection of rainwater was certainly not sufficient, and this cistern was only an intermediary with an external supply. It should be remembered, however, that the amount of water used in the baths could have been quite limited, but this is generally difficult to assess.¹¹⁷

A more obvious indication would be the presence of fountains, which are designed to deliver a continuous stream of water that presupposes an uninterrupted supply upstream. However, there are differences in the sites studied. At Timgad, the fountains located outside the fortress, dating to the Byzantine period, consisted simply of reused sarcophagi with orifices, indicating the presence of a functional water supply. At Leptis Magna, the open-air basin of the Great Nymphaeum could have been used to collect rainwater like

¹¹³ Lassus 1981, 225.

¹¹⁴ Salama 1994, 353.

¹¹⁵ Guerbabi 1994; cf. Lassus 1981, 27–38, part. 36; see also Lassus 1981, 130, fig. 94.

¹¹⁶ Lamare 2017, 108–11; Borau and Alix 2020.

¹¹⁷ Lamare and Rocca 2018.

a cistern or to store water supplied, perhaps irregularly, by a pipe. In comparison, the nymphaeum (7) located at the end of the Chalcidicum cistern is not an obvious testimony to the functioning of a perennial water supply.

The hydraulic network must be evaluated as a whole, including the situation of springs and aqueducts. In Timgad, the spring that rose up near the south of the city was still able to supply the basin from which its water was collected; that basin was restored during the Byzantine period. It is not known, however, whether the Ain Morri spring and the conduit that led its output to the city were still in use. In Sbeitla, the continued existence of the spring until the present day suggests that it has never dried up. However, we must be wary of simplistic conclusions because we still know little about the climatic changes in the southern Mediterranean in antiquity.¹¹⁸ At Leptis Magna, the analyses conducted on the alluvium carried by the Wadi Lebda have made it possible to revise the dating of the destruction of the aqueduct,¹¹⁹ long attributed to the earthquake of 365 CE. This represents another type of natural event for which knowledge must be deepened for ancient North Africa. In Carthage, for instance, Arab sources indicate that the aqueduct was in use until its destruction at the end of the 7th c., which was confirmed by the ceramic deposits in the Cisterns of La Malga.¹²⁰ It had been restored under the Severan dynasty, then probably during the Byzantine period, before being renovated under the Hafsids, as evidenced by the different construction techniques and confirmed by archaeometric analyses.¹²¹ The discovery at Leptiminus of a coin of Constans II in the mortar – dated to 643–47 and used to block the main conduit of the eastern aqueduct in order to divert the flow toward the branch feeding the cisterns near the Eastern Baths – indicates that the water supply through this conduit was still functional at least in the middle of the 7th c.¹²² However, these modifications point out that the water supply was no longer directed toward the center of the ancient city but instead toward this eastern area, around the baths, which were no longer in operation as such.¹²³

Studies in Asia Minor have shown that the water supply in Late Antiquity seemed more targeted, whereas central distribution points, represented by Archaic to Hellenistic fountain-houses, had lost their importance. In several cases, the public function of fountains was even annihilated by pipes that redistributed water directly to consumers, houses, or shops.¹²⁴ In spite of the absence of precise data on the aqueduct, in Sbeitla, there are several indications that water was still flowing through the town: on the one hand, through the existence of a pressurized network and, on the other hand, due to the fountain in the northwest, which attests to a redistribution of water through pipe connections on the balustrade of its basin. In Timgad, either two different systems supplied the city and the fortress, or the city had a limited and irregular supply from the aqueduct, which ensured the supply of the small baths and prompted the installation of the fortress near the spring for strategic reasons, leading to the development of a settlement in the surrounding area. In

¹¹⁸ Manning 2013.

¹¹⁹ Pucci et al. 2011.

¹²⁰ Mosca and Di Stefano 2008, 828, n. 8; cf. Wilson 1998, 93–98.

¹²¹ Figueiredo et al. 2001.

¹²² Ben Lazreg and Mattingly 1992, 301–4.

¹²³ Stirling et al. 2001, 51–69.

¹²⁴ Jacobs and Richard 2012, 55–71.

the case of Leptis Magna, the supply of the Chalcidicum cistern by an aqueduct remains unclear. In any case, no pipe has been identified that indicates that it served as a redistribution node for the surrounding areas. Most dwellings met their water needs from wells and cisterns.¹²⁵ It appears, however, that the area of the Forum Vetus, encircled by a Byzantine wall, may have held several fountains that did not exist during the Imperial period and the supply of which had to be ensured by a reorganization of water distribution. No wells have been identified in this area so far. In another context in the Western Mediterranean, the same phenomenon of reorganization of urban settlement based on the availability of water has been highlighted in Visigothic Spain.¹²⁶

The redistribution of water to preferential areas of activity within a city raises a question about the nature of the archaeological documentation at our disposal. The identifications of “clusters of activity” in Sbeitla¹²⁷ and of a “leopard spot” settlement pattern in Leptis Magna¹²⁸ are based on the very partial results of excavations. However, Byzantine occupation is identified in most of the excavated areas, most often corresponding to the public monuments of the Early Roman Empire that attracted early archaeological attention. Even though there is no doubt that the rest of these cities were occupied during the Imperial period – an idea supported by the presence of an extensive network of roads – the hypothesis of Byzantine occupation over this entire area has rarely been formulated.¹²⁹ The topographical representations of Byzantine settlements are therefore misleading, and the problem of street obliteration only makes them more complex – i.e., are the alluvial deposits that covered part of the streets of Leptis Magna¹³⁰ and the heightening of the streets of Sbeitla¹³¹ indications of the disappearance of the street network? This line of questioning has encouraged reconstructions of scattered zones of activity, not connected by a street system,¹³² even though these elevations, from 50 cm to 1 m (Fig. 9), did not systematically make the maze of roads invisible.

The accessibility of water must also be considered in relation to the security conditions of cities and their fortifications. To do this, it is necessary to distinguish between types of fortifications and the water needs related to them. The fortifications commonly called fortlets were mainly intended to accommodate small mobile garrisons.¹³³ The supply of drinking water for men and horses was ensured by the presence of cisterns identified in most of the forts in the High Steppes region.¹³⁴ In Sbeitla, the fortified houses to the south of the town were equipped with wells or cisterns. The other fortifications could benefit from the water supplied by the aqueduct.¹³⁵

¹²⁵ Munzi 2010, 74–75.

¹²⁶ Martínez Jiménez 2017, 243–45.

¹²⁷ Duval 1982, 620–24; Leone 2007, 184–85.

¹²⁸ Munzi 2010, 75.

¹²⁹ Cf. Fenwick 2013, 22.

¹³⁰ Pucci et al. 2011, 175 and fig. 6.

¹³¹ Duval 1982, 620–22.

¹³² Duval 1982, 621, fig. 10; but Fenwick 2013, 23, fig. 4b represents streets for the city of the 7th–9th c.

¹³³ Pringle 1981, 143–45.

¹³⁴ Lecat 2014.

¹³⁵ Lamare 2017.

The fortresses of larger dimension accommodated stationary garrisons whose strength could vary. In the case of Timgad, the number of men in the garrison was estimated at between 250 and 300.¹³⁶ Citadels or walls surrounding towns were intended to protect the population in the event of a siege. The situation was no longer just military but civilian, no longer mobile but stationary.¹³⁷ In the latter two cases, a large quantity of water had to be easily and continuously accessible to withstand long sieges. The polioretic literature of the Byzantine period refers to these needs.¹³⁸ In the case of Timgad, the basin that gathered water from a nearby spring and whose presence must have dictated the installation of the fortress has already been mentioned. The presence of dwellings installed around this fortification, the population of which could have benefited from protection in the event of an attack, cannot be excluded.

At Leptis Magna, however, the aqueduct that supplied the town on the left bank of the wadi had not been working since the years 355–440 CE. The wells and cisterns were certainly already developed at the time of the construction of Justinian's wall. Because the cistern of the Chalcidicum was still functional, supplied either by rainwater collection or via a pipe, the initial project of the wall had to include it to facilitate the supply inside the enclosure. The reduced wall – the one that was actually completed – would have entailed the development of wells and cisterns in the area of the Forum Vetus while preserving a functional conduit on the right bank. However, the chronology of the development of the fortifications and water resources is uncertain: the Byzantine wall built around the harbor could be justified by the existence of a settlement that was clustered near its water supply by wells and that was engaged in various craft activities during the last century of Byzantine presence.¹³⁹ The question of the anteriority of the fortification or of the water supply cannot clearly be evaluated in the absence of precise dating elements, but the two phenomena are surely interdependent.

The importance of easy access to water is confirmed by the springs, cisterns, wells, or aqueducts reported near many fortifications.¹⁴⁰ In the case of Haidra, in addition to the cisterns long identified below the citadel, a perennial spring at the edge of the wadi immediately outside the fortification probably played a role in the choice of its location.¹⁴¹

Water under control? Hydraulic management and technology

The numerous transformations of hydraulic infrastructure, sometimes on a large scale when aqueduct channels or large public cisterns were involved, presuppose the existence of an authority capable of supervising such projects at least at a local level. As mentioned above, there are hardly any inscriptions in Africa beyond the beginning of the 5th c. CE that provide information on the financing and the officials involved in the management of hydraulic infrastructure. From this date onward, it is mainly legal sources that provide information on the management of water and monuments.

¹³⁶ Pringle 1981, 88.

¹³⁷ Pringle 1981, 145–46.

¹³⁸ Pringle 1981, 164–65; Syrianus Mag., *De Re Strategica* 10.2; Maurice, *Strategikon* 10.4.

¹³⁹ Laronde 1994, 997.

¹⁴⁰ Pringle 1981, 164–65.

¹⁴¹ Baratte and Bejaoui 2010, 519.

A series of imperial rescripts from the 5th c. CE sheds light on the situation of the city of Constantine during the Vandal era. We learn that a delegation of inhabitants of Numidia and Mauretania Sitifensis went to the emperor with several petitions, including one dealing with illegal water intakes from the aqueduct.¹⁴² This claim indicates that the aqueduct was still functioning, given that water intakes were made there, meaning that its maintenance was assured. The rescript of 445 CE also shows that the aggrieved inhabitants probably sought to remedy the lack of local public authority due to the insufficient number of curiales in the cities after the departure of many prominent citizens from the province of Numidia in the wake of the Vandal conquest.¹⁴³

The paucity of information provided by the *Digest* about water management outside Rome and Constantinople indicates that city administrations played a leading role in this issue. Consequently, one must consider the persistence of local water magistrates and, probably, regional or even local regulations as during Early Roman times.¹⁴⁴ The argument supports a continuity in the administrative activities of the cities, which assumed responsibility for water management. In Ostrogothic Italy, many aqueducts and baths were repaired, but the nature and source of the funds to pay for these operations are not known. Although Theodoric himself financed some restorations, routine maintenance was the responsibility of the local authorities. The technical and administrative means were therefore the same as those used in previous centuries.¹⁴⁵ The part taken by the Church in the management and financing of water infrastructure, as in the rest of city maintenance, is attested in some cases¹⁴⁶ but remains much debated,¹⁴⁷ so examples from the Eastern Mediterranean can be extrapolated neither to the West nor to Africa.¹⁴⁸

Economic considerations must be taken into account, even if we are very poorly informed about the funding sources for major buildings, such as churches and luxurious private baths, of the Byzantine period in contrast to the sources available for the Near East at the same time.¹⁴⁹ When restorations were limited – such as in the case of Timgad, where the water supply was still provided by the spring and only the basin needed to be repaired – the human and financial resources were sufficient (even more so here because the army was involved). In Sbeitla, the prosperity of the city is attested by the numerous constructions of Christian cult buildings and, on the administrative and political level, it has been suggested that the city became the residence of the dux of Byzacena.¹⁵⁰ Assuming that the aqueduct was still functioning, perhaps thanks to minor repairs over time, the transformation of fountains and the installation of additional pipes in the city did not raise any financial difficulties. These proactive measures taken to manage the water supply and its eventual scarcity can be understood as a sign of urban vitality

¹⁴² Ronin 2018.

¹⁴³ Ronin 2018, 148–49.

¹⁴⁴ Saliou 1994, 151–52; Bruun 2012, 18–26.

¹⁴⁵ Marano 2015, 166–69.

¹⁴⁶ E.g., at Gortyn: Giorgi 2008, 313.

¹⁴⁷ Marano 2015, 169 contra Martínez Jiménez 2010, 272; Martínez Jiménez and González Gutiérrez 2017, 242–43; Ward-Perkins 1984, 131–32.

¹⁴⁸ Cf. Leone 2011, 14–15.

¹⁴⁹ Duval 2006, 133.

¹⁵⁰ Duval 1971b, 430–31.

rather than the parallel process of an irretrievable decline.¹⁵¹ However, it seems that when the damage was too severe, for example following violent events, the economic capacities were no longer sufficient to restore the entire system. This was probably the case at Leptis Magna,¹⁵² which could not cope with the silting up that began ca. 355–440 CE after the breaking of the dam of the wadi. Whereas the dynamism of Vandal–Byzantine urbanism was sufficient to transform and remodel parts of the cities, it was unable to handle the entirety of the formerly occupied areas.¹⁵³ Hydraulic infrastructure certainly suffered from this maintenance problem.

One might consider the loss of technical knowledge or specialized manpower to be factors influencing water management. However, some texts testify to a very real know-how and interest in the field of irrigation. Procopius evokes the mastery of hydraulic installations in a passage that refers to Solomon's campaigns in 539–40 CE.¹⁵⁴ The notarial deeds that are recorded in the Albertini tablets, dating to the Vandal period, also evoke the control and management of water for crops. Archaeology has, moreover, highlighted the development of hydraulic techniques linked to the exploitation of the landscape up to the Byzantine period and, precisely in the region of the Tunisian High Steppes, the importance of Late Antique dams has recently been highlighted – for example, at Kasserine and Sbeitla.¹⁵⁵ In an urban context, it has been shown that the decline in the number of engineers and their disappearance in the Western Mediterranean was visible in the constructions of the 6th–7th c. CE. However, in the Eastern Mediterranean and in the western territories reconquered by Justinian, there is some evidence in favor of the presence of state-protected engineers. These engineers were associated with major projects, such as those of Theodoric in Italy or the construction of a new aqueduct at Reccopolis by Leovigild in the 5th c. The latter, however, is one among very few other examples from that time.¹⁵⁶ The continued functioning of aqueducts depended on the interest of the elites in this type of restoration and on continuous maintenance, but it could not be ensured by major reconstructions or restorations.¹⁵⁷ Four of the aqueducts in Rome, for example, were kept in use until the end of the Middle Ages. The aqueducts were used to supply mainly episcopal complexes and water mills in addition to the baths of churches or charitable institutions, and perhaps even the Baths of Caracalla. The repairs, implemented by the Byzantine administration and then, from the end of the 8th c., by the papacy, copied the techniques of the Roman period.¹⁵⁸

Security or scarcity? Perception of water resources

Restorations or new installations for hydraulic supply testify to a willingness (and a need) to make the access to water possible in cities, whether fortified or not, close to places

¹⁵¹ Jacobs and Richard 2012, 63–65, 71.

¹⁵² Pucci et al. 2011, 183–84.

¹⁵³ Thébert 1983, 119–20; see the contributions of R. Ghaddab and A. Leone in Panzram and Callegarin 2018.

¹⁵⁴ Proc., *Vand.* 2.19.11–13.

¹⁵⁵ Baratte 2014.

¹⁵⁶ Martínez Jiménez and González Gutiérrez 2017, 42–43.

¹⁵⁷ Martínez Jiménez and González Gutiérrez 2017, 44–45.

¹⁵⁸ Coates-Stephens 1998, 171–78.

of activity. This reorganization of hydraulic networks reveals either a poor adaptation to a decaying urban hydraulic system or a great capacity of communities to adapt and react flexibly with regard to urban facilities.

Up until the 4th c. CE, numerous African inscriptions mention the restoration of monuments, particularly those with a hydraulic purpose. Insistence on the lack of maintenance and the restored functioning of such monuments, mentions of the *incuria* of previous generations, and transformations carried out for the well-being of the people are elements of a rhetorical stance that was, nevertheless, most probably based on material realities.¹⁵⁹ In the 6th c., in contrast, the inscriptions do not evoke this type of restoration but instead focus almost exclusively on the construction of fortifications.¹⁶⁰

Literary sources, mainly concerned with the Eastern Mediterranean, provide essential information on the strategies implemented and on the perception of urban water transformations. Procopius's *De Aedificiis* is a major source. The references relating to hydraulic engineering¹⁶¹ emphasize the economic advantages of water resources, making cisterns and reservoirs a positive tool through which emperors could create abundance out of scarcity. Similarly, in many 5th–6th c. CE chronicles of Constantinople, the pattern of open pools and cisterns becomes recurrent. The proliferation of these structures within walls indicates a need for security.¹⁶²

Despite a few references by Procopius to Africa, Evagrius Scholasticus provides a more important testimony for this discussion: in this region, Justinian restored many cities and adorned them with various public buildings and walls, as well as with “water-conduits both for essential need and beauty.”¹⁶³ These monuments were built from scratch when the cities did not have them, or they were repaired “and brought back again to their ancient order.”¹⁶⁴ The rhetoric analyzed by Yves Modéran consists of a return to the “classical city” – a city that the learned pictured very clearly, particularly due to their classicizing culture.¹⁶⁵ Two inscriptions recently found in Algeria – the oldest known to date before the Byzantine reconquest – confirm that the municipal ideal was still vivid until the mid-5th c. CE.¹⁶⁶

Yet, archaeological sources show us that the hydraulic system, in particular, was never restored to its Early Imperial condition. In fact, the elites restored an “idea of the city” from the Classical period, based on bookish knowledge, while adding new characteristic elements – particularly walls, which became an essential component of the urban ideal in the Byzantine period.¹⁶⁷ For the people, who did not have access to this knowledge of the past, there was no personal memory that could go beyond two or three generations. The contemporary state of the city and its waterworks was a fact, and only inscriptions

¹⁵⁹ Lepelley 1999, 247; Davoine 2015, 96–104.

¹⁶⁰ Modéran 1996, 88–89.

¹⁶¹ Pickett 2017.

¹⁶² Crow 2008, 271.

¹⁶³ Modéran 1996, 105–6.

¹⁶⁴ Evagr., *Eccl. Hist.* 4.18 (trans. Whitby 2000, 218).

¹⁶⁵ Modéran 1996, 107 and *passim*.

¹⁶⁶ Chalal and Dupuis 2020, 93–94.

¹⁶⁷ Leone 2007, 193–94.

– if they existed – or imperial or local political discourse provided certain images of the past. Evoking the idea of decline or simply transformation only makes sense when long-term knowledge is possible. The testimony of Cassiodorus shows that in 6th c. CE Italy, the ideal of the classical city was still strong and the pleasures of bathing were an integral part of urban life.¹⁶⁸

Authorities still used water as an essential symbol of their power but, as opposed to the images of profusion and the “eternity of water”¹⁶⁹ associated with other water monuments during the Early Roman Empire, cisterns became structures worthy of praise in Procopius’s text,¹⁷⁰ which testifies to an important change in the perception of water resources and their management. In these examples from the Eastern Mediterranean, that power insisted on the storage of water and its guaranteed availability. Despite a decline in the implementation and maintenance of hydraulic infrastructure, people perceived their city as safe and their governing elites as protective. North Africa certainly experienced this paradigm shift as well.

Conclusion

The late use of aqueducts can be traced by identifying the operation of hydraulic monuments up to a late date. This approach only provides a terminus ad quem that must be clarified where possible by stratigraphic excavations to identify the phases of abandonment, and by archaeometric analyses of carbonate deposits found on the aqueducts and other potential hydraulic buildings.¹⁷¹

An aqueduct conduit needed to be in a certain condition for the water to flow properly, including both an unbroken path and a sufficiently well-maintained internal conduit.¹⁷² Even if such networks were still functional, their condition was not the same as that of the original networks: the distribution of water was different within the urban space, depending on the supply branches that were still in use. The state of preservation or restoration of the pipes may have conditioned the development of housing or fortifications in certain areas of a city. Craftsmen and inhabitants were also able to manage their water needs by means of wells or cisterns and, in some cases, transformed the network to supply workshops and houses by taking water from cisterns or old fountains transformed into redistribution basins. The topography of Byzantine African cities must, however, be reevaluated so that researchers are not misled by plans representing the results of partial excavations. The correlation between urban settlement and water availability should then be emphasized.

The situation of each city was unique, depending on its importance, its administrative and economic context, and the natural events it experienced. The presence of a Byzantine garrison in Timgad facilitated the works that were carried out by the army, whereas the

¹⁶⁸ Fauvinet-Ranson 2006, 220.

¹⁶⁹ *IRT* 358.

¹⁷⁰ Pickett 2017.

¹⁷¹ I am planning isotope analyses on carbonate deposits from the aqueduct of Sbeitla, with funding from the Cluster of Excellence ROOTS, in cooperation with the Institut national du patrimoine in Tunis. The results should provide first insights into the chronology of the aqueduct and the climatic conditions in this region.

¹⁷² Borau 2019.

prosperity of Sbeitla, visible in the construction of Christian basilicas, indicates that the repairs probably did not pose a financial problem, although the origin of the funds – possibly the Church – is not known. The more difficult circumstances in Leptis Magna, as in the province of Tripolitania in general, which faced numerous attacks from tribes from the hinterland and the progressive silting up of the city and the port, were such that complex and costly repairs had to be limited in this city, which had been partially abandoned before the arrival of the Byzantine troops. Even if manpower and technical knowledge had not been lost, the cities themselves or their elites had to ensure the financing of the hydraulic infrastructure and their economic and administrative situation did not necessarily allow them to attend to the most important works.

Notions of decline and continuity may be nuanced and analyzed from individual, subjective perspectives. Even if one cannot determine the former point of view – given that the sources, which are already few in number, reflect the mentality of the learned elite – it must be borne in mind that the image that the inhabitants themselves had of their city could not have been built on a very old referent. The identification of hydraulic systems, even limited ones, in working order, shows the adaptability of the populations facing unexpected events, which must be further analyzed.¹⁷³

The study of water requires a broader perspective than that of anthropogenic data alone. The construction of complementary branches of many ancient aqueducts has generally been interpreted either as an additional need for water, as a response to a decrease in flow, or as a drying up of the spring originally tapped to supply a city (for example, in Timgad). Archaeometric studies must come into play to improve our knowledge of natural data, including the analysis of the carbonate deposits found in the conduits. Study of the superimposition of the limestone layers deposited by the water flow and the analysis of the stable isotopes of these concretions will make it possible to enhance chronological precision regarding the duration of use. It will complement the information relating to the origin and flow rate of the water used in one or more aqueducts and allow reconstruction of the evolution of water resources and climatic conditions,¹⁷⁴ particularly at the end of antiquity,¹⁷⁵ which differed across the empire¹⁷⁶ and within the Maghreb.¹⁷⁷ Comparisons of the transformations highlighted by archaeology and natural data will enable an evaluation of the resilience of past societies in the face of slow climatic change as well as more violent events and will provide a new perspective on the urban world between Antiquity and the Middle Ages.

Acknowledgments: First versions of this work were prepared as part of a DAAD postdoctoral research grant at the Freie Universität Berlin and were presented in Berlin, Tübingen, and Paris. This article was written at Kiel University with funding of the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2150 ROOTS – 390870439. I would like to thank François Baratte, Cristina Murer, and Roberta Ferritto, who reviewed the first drafts of this study; the anonymous reviewers of the JRA for their comments; and Eileen Küçükkaraca for revising the English text. All views and errors remain my own.

¹⁷³ Christie 2018.

¹⁷⁴ Sürmelihiindi et al. 2013.

¹⁷⁵ Büntgen et al. 2016.

¹⁷⁶ Manning 2013, 153–66; Wilson 2013, 261–66.

¹⁷⁷ Leveau 2014.

References

- Ballu, A. 1914. "Rapport sur les fouilles exécutées en 1913 par le service des monuments historiques de l'Algérie." *BAC*, 270–329.
- Baratte, F. 2014. "Barrages des Hautes Steppes tunisiennes: quelques observations préliminaires." In *Regards croisés d'Orient et d'Occident: les barrages dans l'Antiquité tardive: Actes du colloque, 7–8 janvier 2011, Paris, Fondation Simone et Cino del Luca organisé dans le cadre du programme ANR EauMaghreb*, ed. F. Baratte, C. J. Robin, and E. Rocca, 165–74. Orient & Méditerranée – Archéologie 14. Paris: De Boccard.
- Baratte, F., and F. Bejaoui. 2010. "Les fortifications byzantines d'Ammaedara." *CRAI* 154, no. 1: 513–38. DOI:10.3406/crai.2010.92840.
- Baratte, F., F. Béjaoui, and N. Duval, eds. 2014. *Basiliques chrétiennes d'Afrique du Nord: inventaire et typologie. II, Inventaire des monuments de la Tunisie*. Bordeaux: Ausonius.
- Bejaoui, F. 1996. "Nouvelles données archéologiques à Sbeitla," *Africa* 14, 37–63.
- Bejaoui, F. 2018. "Le réseau hydraulique de Sufetula (Sbeitla, Tunisie): état de la question." In *L'eau dans les villes du Maghreb et leur territoire à l'époque romaine*, ed. V. Brouquier-Reddé and F. Hurlet, 225–34. Bordeaux: Ausonius.
- Ben Lazreg, N., and D.J. Mattingly 1992. *Leptiminus (Lamta). A Roman port city in Tunisia. Report no. 1*. JRA Suppl. 4. Ann Arbor: University of Michigan.
- Bockmann, R., A. Leone, and P. von Rummel, eds. 2019. *Africa – Ifrīqiya: Continuity and Change in North Africa from the Byzantine to the Early Islamic Age. Papers of a Conference Held in Rome, Museo Nazionale Romano – Terme di Diocleziano, 28 February – 2 March 2013*. Wiesbaden: Harrassowitz.
- Borau, L. 2019. "Entretien et restauration des aqueducs: quels indices archéologiques? L'exemple de la Gaule romaine." In *Instandhaltung und Renovierung von Straßen und Wasserleitungen von der Zeit der römischen Republik bis zur Spätantike*, ed. M. Ronin and C. Möller, 181–214. Baden-Baden: Nomos. DOI:10.5771/9783748900269-181.
- Borau, L., and S. Alix. 2020. "Les aqueducs de Gaule romaine de l'Antiquité tardive, entre construction, restauration et abandon." *AnTard* 28: 53–66. DOI:10.1484/J.AT.5.122353.
- Brogio, G. P., and B. Ward-Perkins, eds. 1999. *The Idea and Ideal of the Town between Late Antiquity and the Early Middle Ages*. Transformation of the Roman World 4. Leiden and Boston: Brill.
- Bruun, C. 2012. "Roman emperors and legislation on public water use in the Roman Empire: Clarifications and problems." *Water History* 4, 11–33.
- Büntgen, U., V. S. Myglan, F. C. Ljungqvist, M. McCormick, N. Di Cosmo, M. Sigl, J. Jungclauss, S. Wagner, P. J. Krusic, J. Esper, J. O. Kaplan, M. A. C. de Vaan, J. Luterbacher, L. Wacker, W. Tegel, and A. V. Kirydanov. 2016. "Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD." *Nature Geoscience* 9 (3): 231–6. DOI:10.1038/ngeo2652.
- Caputo, G. 1987. *Il teatro augusteo di Leptis Magna: scavo e restauro, 1937–1951*. Monografie di archeologia libica 22. Rome: L'Erma di Bretschneider.
- Cèbe, J.-P. 1957. "Une fontaine monumentale récemment découverte à Sufetula (Byzacène)." *MÉFR* 69 (1): 163–206. DOI:10.3406/mefr.1957.7416.
- Chalal, B., and X. Dupuis. 2020. "Felix civitas Valentinianopolis. Une cité de Numidie au milieu du V^e siècle." *BAAIq* 8: 73–99.
- Christie, N. 2018. "Changing data and changing interpretations in the study of transformations of late antique space and society." In *Interpreting Transformations of People and Landscapes in Late Antiquity and the Early Middle Ages: Archaeological Approaches and Issues*, ed. P. Diarte-Blasco and N. Christie, 13–25. Philadelphia and Oxford: Oxbow.
- Coates-Stephens, R. 1998. "The walls and aqueducts of Rome in the Early Middle Ages, A.D. 500–1000." *JRS* 88: 166–78. DOI:10.2307/300810.
- Courtois, C. 1951. *Timgad: Antique Thamogadi*. Alger: Imprimerie Officielle.
- Crova, B. 1967. "Opere idrauliche romane all'Uadi Caàm, il Cinyps della Tripolitania romana." *QAL* 5: 99–120.
- Crow, J. 2008. "The infrastructure of a great city: Earth, walls and water in late antique Constantinople." In *Technology in Transition A.D. 300–650*, ed. L. Lavan, E. Zanini, and A. Sarantis, 251–85. Late Antique Archaeology 4. Leiden: Brill. DOI:10.1163/ej.9789004165496.i-573.101.

- Crow, J., J. Bardill, and R. Bayliss. 2008. *The Water Supply of Byzantine Constantinople*. JRS Monographs 11. London: Society for the Promotion of Roman Studies.
- Davoine, C. 2015. "Recherches sur les ruines dans le monde romain: gestion et perception des bâtiments détruits dans la cité romaine (Ier siècle av. J.-C.–IVe siècle ap. J.-C.)." PhD diss., Univ. Paris 8.
- Dewing, H. B. 1916. *Procopius: History of the Wars*. Vol. II. Books 3–4 (Vandalic War). Loeb Classical Library 81. London and Cambridge: W. Heinemann.
- Di Vita, A., G. Di Vita-Évrard, L. Bacchielli, and R. Polidori. 1998. *La Libye antique: cités perdues de l'Empire romain*. Paris: Mengès.
- Durliat, J. 1981. *Les dédicaces d'ouvrages de défense dans l'Afrique byzantine*. CÉFR 256. Rome: École française de Rome.
- Duval, N. 1971a. *Les églises africaines à deux absides: recherches archéologiques sur la liturgie chrétienne en Afrique du Nord. Recherches archéologiques à Sbeitla*. Vol. I: *Les basiliques de Sbeitla à deux sanctuaires opposés (basiliques I, II et IV)*. BÉFAR 218. Rome: École française de Rome.
- Duval, N. 1971b. "Inscriptions byzantines de Sbeitla (Tunisie), III." *MÉFR* 83 (2): 423–43. DOI:10.3406/mefr.1971.917.
- Duval, N. 1982. "L'urbanisme de Sufetula: Sbeitla en Tunisie." *ANRW* II.10.2: 596–632.
- Duval, N. 2006. "L'Afrique dans l'Antiquité tardive et la période byzantine: l'évolution de l'architecture et de l'art dans leur environnement." *AnTard* 14: 119–64. DOI:10.1484/J.AT.2.302427.
- Fauvinet-Ranson, V. 2006. *Decor civitatis, decor Italiae. Monuments, travaux publics et spectacles au VI^e siècle d'après les Variae de Cassiodore*. Munera 23. Bari: Edipuglia.
- Fenwick, C. 2013. "From Africa to Ifriqiya: Settlement and society in early medieval North Africa (650–800)." *Al-Masāq* 25 (1): 9–33. DOI:10.1080/09503110.2013.767008.
- Figueiredo, M.O., J.P. Veiga and T.P. Silva 2001. "Materials and reconstruction techniques at the Aqueduct of Carthage since the Roman period." In *Historical Constructions: Possibilities of Numerical and Experimental Techniques. Proceedings of the 3rd International Seminar, Guimarães, Portugal, University of Minho, 7–9 November 2001*, ed. P.B. Lourenço and P. Roca. Guimarães: University of Minho.
- Giorgi, E. 2008. "Water technology at Gortyn in the 4th–7th c. A.D.: Transport, storage and distribution." In *Technology in Transition A.D. 300–650*, ed. L. Lavan, E. Zanini, and A. Sarantis, 287–320. Late Antique Archaeology 4. Leiden and Boston: Brill. DOI:10.1163/22134522-90000092.
- Goodchild, R. G., and J. B. Ward-Perkins. 1953. "The Roman and Byzantine defences of Lepcis Magna." *PBSR* 21: 42–73.
- Guerbabi, A. 1994. "Chronométrie et architecture antiques: le gnomon du forum de Thamugadi." In *L'Africa romana. Atti del X Convegno di Studio, Oristano, 11–13 dicembre 1992*, ed. A. Mastino and P. Ruggeri, 359–402. Sassari: Editrice Archivio Fotografico Sardo.
- Gui, I., N. Duval, and J.-P. Caillet. 1992. *Basiliques chrétiennes d'Afrique du nord: inventaire et typologie*. Paris: Institut d'Études Augustiniennes.
- Hodge, A. T. 2002. *Roman Aqueducts & Water Supply*. London: Duckworth.
- Jacobs, I., and J. Richard. 2012. "'We surpass the beautiful waters of other cities by the abundance of ours': Reconciling function and decoration in late antique fountains." *Journal of Late Antiquity* 5: 3–71.
- Lamare, N. 2017. "La fontaine à cour et l'hydraulique tardive de Sbeitla. Nouvelles observations." *AntAfr* 53: 95–114. DOI:10.4000/antafr.644.
- Lamare, N. 2019a. *Les fontaines monumentales en Afrique romaine*. CÉFR 557. Rome: École française de Rome.
- Lamare, N. 2019b. "*Lacum uetustate conlabsum restituere*: restaurations et transformations des fontaines monumentales d'Afrique tardive." In *Instandhaltung und Renovierung von Straßen und Wasserleitungen von der Zeit der römischen Republik bis zur Spätantike*, ed. M. Ronin and C. Möller, 215–36. Baden-Baden: Nomos. DOI:10.5771/9783748900269-215.
- Lamare, N., and C. Murer, eds. 2020. *L'eau dans la ville tardo-antique*. Turnhout: Brepols.
- Lamare, N., and E. Rocca. 2018. "L'usage de l'eau dans les grands thermes publics d'Ammaedara (Haïdra, Tunisie)." In *L'eau dans les villes du Maghreb et leur territoire à l'époque romaine*, ed. V. Brouquier-Reddé and F. Hurlet, 193–214. Bordeaux: Ausonius.
- Laporte, J.-P. 2018. "Timgad : le sanctuaire de l'Aqua Septimiana, source donnée aux hommes par le *Genius patriae* et la *Dea patria*." In *Du culte aux sanctuaires. L'architecture religieuse dans l'Afrique*

Thirsty cities? Water in Byzantine North Africa

- romaine et byzantine. *Actes du colloque, 18–19 avril 2013, Paris, Fondation Simone et Cino del Duca*, ed. F. Baratte, V. Brouquier-Reddé, and E. Rocca, 195–212. Paris: De Boccard.
- Laronde, A. 1994. "Nouvelles recherches archéologiques dans le port de Lepcis Magna." *CRAI* 138 (4): 991–1006. DOI:10.3406/crai.1994.15429.
- Lassus, J. 1981. *La forteresse byzantine de Thamugadi. Vol. I, Fouilles à Timgad, 1938–1956*. Paris: CNRS Éditions.
- Lecat, Z. 2014. "Recherches sur les fortifications des Hautes Steppes (Tunisie) à l'époque byzantine." PhD diss., Univ. Paris-Sorbonne.
- Leone, A. 2007. *Changing Townscapes in North Africa from Late Antiquity to the Arab Conquest*. Munera 28. Bari: Edipuglia.
- Leone, A. 2011. "Bishops and territory: The case of late Roman and Byzantine North Africa." *DOP* 65/66: 5–27.
- Lepelley, C. 1999. "Témoignages épigraphiques sur le contrôle des finances municipales par les gouverneurs à partir du règne de Dioclétien." In *Il capitolò delle entrate nelle finanze municipali in occidente ed in oriente. Actes de la 10. rencontre franco-italienne sur l'épigraphie du monde romain, Rome, 27–29 mai 1996*, 235–47. CÉFR 256. Rome: École française de Rome.
- Leveau, P. 2014. "Évolution climatique et construction des ouvrages hydrauliques en Afrique romaine." In *Regards croisés d'Orient et d'Occident: les barrages dans l'Antiquité tardive. Actes du colloque, 7–8 janvier 2011, Paris, Fondation Simone et Cino del Luca, organisé dans le cadre du programme ANR EauMaghreb*, ed. F. Baratte, C. J. Robin, and E. Rocca, 125–38. Paris: de Boccard.
- Lichtenberger, A., and R. Raja. 2019. "Management of water resources over time in semiarid regions: The case of Gerasa/Jerash in Jordan." *WIREs Water* 7 (1). DOI:10.1002/wat2.1403.
- Lohmann, H. 1978. "Beobachtungen zum Stadtplan von Timgad." In *Wohnungsbau im Altertum. Bericht über ein Kolloquium in Berlin vom 21.11. bis 23.11.1978*, 167–87. Berlin: Deutsches Archäologisches Institut.
- Loseby, S. T. 2009. "Mediterranean cities." In *A Companion to Late Antiquity*, ed. P. Rousseau and J. Raithel, 139–55. Chichester and Malden: Wiley-Blackwell.
- Manning, S. W. 2013. "The Roman world and climate: Context, relevance of climate change, and some issues." In *The Ancient Mediterranean Environment between Science and History*, ed. W. V. Harris, 103–70. Columbia Studies in the Classical Tradition 39. Leiden and Boston: Brill. DOI:10.1163/9789004254053_007.
- Marano, Y. 2015. "'Watered... with the life-giving wave.' Aqueducts and water management in Ostrogothic Italy." In *Ownership and Exploitation of Land and Natural Resources in the Roman World*, ed. P. Erdkamp, K. Verboven, and A. J. Zuiderhoek, 150–69. Oxford: Oxford University Press.
- Maréchal, S. 2020. *Public Baths and Bathing Habits in Late Antiquity: A Study of the Evidence from Italy, North Africa and Palestine A.D. 285–700*. Late Antique Archaeology (Supplementary Series) 6. Leiden and Boston: Brill.
- Martínez Jiménez, J. 2010. "El uso y suministro de agua a la ciudad de Roma en el periodo Ostrogodo: 476–552 DC." In *Espacios urbanos en el occidente mediterráneo (s. VI–VIII)*, ed. A. García, 267–74. Toledo: Toletum Visogodo.
- Martínez Jiménez, J. 2017. "Water supply in the Visigothic urban foundations of Eio (El Tolmo de Minateda) and Reccopolis." In *New Cities Late Antiquity: Documents and Archaeology*, ed. E. Rizos, 233–45. Bibliothèque de l'Antiquité tardive 35. Turnhout: Brepols.
- Martínez Jiménez, J. 2020. *Aqueducts and Urbanism in Post-Roman Hispania*. Piscataway, NJ: Gorgias Press.
- Martínez Jiménez, J., and P. González Gutiérrez. 2017. "Knowledge and specialised trades in the late antique West: medicine vs engineering." *Journal of Late Antique Religion and Culture* 11: 38–58. DOI:10.18573/j.2017.10451.
- Mattingly, D. J. 1995. *Tripolitania*. London: B. T. Batsford.
- Modéran, Y. 1996. "La renaissance des cités dans l'Afrique du VI^e siècle d'après une inscription récemment publiée." In *La fin de la cité antique et le début de la cité médiévale de la fin du III^e siècle à l'avènement de Charlemagne. Actes du colloque tenu à Paris les 1, 2 et 3 avril 1993*, ed. C. Lepelley, 85–114. Munera 8. Bari: Edipuglia.
- Modéran, Y. 2003. *Les Maures et l'Afrique romaine: IV^e–VII^e siècle*. BÉFAR 314. Rome: École française de Rome.

- Mosca, A., and G. Di Stefano 2008. "Una fontana a cascata a Cartagine: considerazioni sulla sistemazione urbanistica dell'area la Malga." In *L'Africa romana. Le ricchezze dell'Africa: risorse, produzioni, scambi. Atti del XVII convegno di studio, Sevilla, 14–17 dicembre 2006*, ed. J. González Fernández, 857–77. Rome: Carocci.
- Munzi, M. 2010. "Il territorio di Leptis Magna. Insediamenti rurali, strutture produttive e rapporti con la città." In *Leptis Magna: una città e le sue iscrizioni in epoca tardoantica*, ed. I. Tantillo and F. Bigi, 45–80. Cassino: Edizioni dell'Università degli Studi di Cassino.
- Munzi, M., F. Felici, and G. Schirru. 2003. "Una bottiglia tardoantica con iscrizione dal teatro di Leptis Magna." *Archeologia Medievale* 30: 549–56.
- Panzram, S., and L. Callegarin, eds. 2018. *Entre civitas y madīna: el mundo de las ciudades en la Península Ibérica y en el Norte de África (siglos I–IX)*. Madrid: Casa de Velázquez.
- Paulin, M. 2015. "Quelques questions sur le système de distribution d'eau dans les Thermes du Levant à Leptis Magna (Libye)." In *De Leptis Magna à Derna, de la Tripolitaine à la Cyrénaïque. Travaux récents sur la Libye antique*, ed. V. Michel, 151–74. Paris: Riveneuve.
- Pentiricci, M. 2010. "L'attività edilizia a Leptis Magna tra l'età tetrarchica e il V secolo: una messa a punto." In *Leptis Magna: una città e le sue iscrizioni in epoca tardoantica*, ed. I. Tantillo and F. Bigi, 97–171. Cassino: Edizioni dell'Università degli Studi di Cassino.
- Pickett, J. 2016. "Temples, churches, cisterns and pipes: Water in late antique Ephesus." In *De aquaeductu atque aqua urbium Lyciae Pamphyliae Pisidiae: The Legacy of Sextus Julius Frontinus. Tagungsband des internationalen Frontinus-Symposiums, Antalya, 31. October–9. November 2014*, 297–311. BABESCH Supplement 27. Leuven: Peeters.
- Pickett, J. 2017. "Water and empire in the *De aedificiis* of Procopius." *DOP* 71: 95–125.
- Pringle, D. 1981. *The Defence of Byzantine Africa from Justinian to the Arab Conquest: An Account of the Military History and Archaeology of the African Provinces in the Sixth and Seventh Centuries*. BAR International Series 99. Oxford: British Archaeological Reports.
- Pucci, S., D. Pantosti, P. M. De Martini, A. Smedile, M. Munzi, E. Cirelli, M. Pentiricci, and L. Musso. 2011. "Environment-human relationships in historical times: The balance between urban development and natural forces at Leptis Magna (Libya)." *Quaternary International* 242 (1): 171–84. DOI:10.1016/j.quaint.2011.03.050.
- Ricciardi, M. 2005. "Il tempio di Milk'Ashtart Ercole." In *I tre templi del lato nord-ovest del Foro Vecchio a Leptis Magna*, ed. A. Di Vita and M. Livadiotti, 309–93. Rome: L'Erma di Bretschneider.
- Romanelli, P. 1925. "Primi studi e ricerche sulle opere idrauliche di Leptis Magna e sull'approvvigionamento d'acqua della città." *Rivista della Tripolitania* 1–4: 209–28.
- Ronin, M. 2018. "L'eau dans la cité après le passage des Vandales. Constantine en 445 (Nov. Val. XIII)." In *Ravenna capitale. Il diritto delle acque nell'Occidente tardoantico: utilità comune e interessi privati*, ed. G. Bassanelli Sommariva and L. Maganzani, 139–51. Santarcangelo di Romagna: Maggioli editore.
- Salama, P. 1994. "Entrées et circulation dans Timgad. Etude préliminaire." In *L'Africa romana. Atti del X convegno di studio, Oristano, 11–13 dicembre 1992*, ed. A. Mastino and P. Ruggeri, 347–57. Sassari: Editrice Archivio Fotografico Sardo.
- Saliou, C. 1994. *Les lois des bâtiments: voisinage et habitat urbain dans l'Empire romain. Recherches sur les rapports entre le droit et la construction privée du siècle d'Auguste au siècle de Justinien*. Bibliothèque archéologique et historique 116. Beirut: Institut français du Proche-Orient. DOI:10.4000/books.ifpo.6125.
- Sandoz, C. 2004. "Les nymphées de Lepcis Magna: aperçu préliminaire." In *L'Africa romana. Ai confini dell'Impero: contatti, scambi, conflitti, Atti del XV convegno di studio, Tozeur, 11–15 dicembre 2002*, ed. M. Khanoussi, P. Ruggeri, and C. Vismara, 1789–808. Rome: Carocci.
- Sandoz, C. 2006. "The nymphaeum of Sabratha and the great Severan nymphaeum of Lepcis Magna (Libya): Supply and hydraulic system." In *Cura aquarum in Ephesus, International Congress on the History of Water Management and Hydraulic Engineering in the Mediterranean Region, Ephesus-Selçuk, Turkey, October 2–10, 2004*, 401–8. BABESCH Suppl. 12. Dudley: Peeters.
- Schmölder-Veit, A. 2009. *Brunnen in den Städten des westlichen Römischen Reiches*. Palilia 19. Wiesbaden: L. Reichert.

Thirsty cities? Water in Byzantine North Africa

- Stirling, L.M., D. J. Mattingly, and N. Ben Lazreg. 2001. *Leptiminus (Lamta): A Roman Port City in Tunisia. Report 2: The East Baths, Cemeteries, Kilns, Venus Mosaic, Site Museum, and Other Studies*. JRA Suppl. 41. Portsmouth: Journal of Roman Archaeology.
- Sürmelihiindi, G., C. W. Passchier, C. Spötl, P. Kessener, M. Bestmann, D. E. Jacob, and O. N. Baykan. 2013. "Laminated carbonate deposits in Roman aqueducts: Origin, processes and implications." *Sedimentology* 60 (4): 961–82. DOI:10.1111/sed.12000.
- Thébert, Y. 1983. "L'évolution urbaine dans les provinces orientales de l'Afrique romaine tardive." *Opus* 2: 99–130.
- Thébert, Y. 2003. *Thermes romains d'Afrique du Nord et leur contexte méditerranéen: études d'histoire et d'archéologie*. BÉFAR 315. Rome: École française de Rome.
- Tomasello, F. 2005. *Fontane e ninfei minori di Leptis Magna*. Monografie di Archeologia Libica 27. Rome: L'Erma di Bretschneider.
- Ward-Perkins, B. 1984. *From Classical Antiquity to the Middle Ages: Urban Public Building in Northern and Central Italy, AD 300–850*. Oxford and New York: Oxford University Press.
- Ward-Perkins, J.B., ed. 1993. *The Severan Buildings of Lepcis Magna: an Architectural Survey*. Society for Libyan Studies monograph no. 2. London: Society for Libyan Studies.
- Whitby, M. T. P. 2000. *The Ecclesiastical History of Evagrius Scholasticus*. Translated Texts for Historians 33. Liverpool: Liverpool University Press.
- Wilson, A. 1997. "Water management and usage in Roman North Africa: A social and technological study." PhD diss., Oxford Univ.
- Wilson, A. 1998. "Water supply in ancient Carthage." In *Carthage Papers: The Early Colony's Economy, Water Supply, a Public Bath, and the Mobilization of State Olive Oil*, ed. J. T. Peña, 65–102. JRA Suppl. 28. Portsmouth, RI: Journal of Roman Archaeology.
- Wilson, A. 2002. "Urban production in the Roman world: The view from North Africa." *PBSR* 70: 231–73. DOI:10.1017/S0068246200002166.
- Wilson, A. 2013. "The Mediterranean environment in ancient history: Perspectives and prospects." In *The Ancient Mediterranean Environment between Science and History*, ed. W. V. Harris, 259–76. Columbia Studies in the Classical Tradition 39. Leiden and Boston: Brill. DOI:10.1163/9789004254053_012.