INNOVATION IN HYDRAULIC INSTALLATIONS: THE CASE OF MOTYA

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The study focuses on identifying different water systems in the island of Motya during the first half of the 1st millennium BC (Iron Age - Archaic Period / 800-480 BC). The location in the Marsala Lagoon on the Western tip of Sicily and the presence of freshwater was fundamental for the birth of the first settlement. The introduction of innovative elements in the field of hydraulics has allowed the city to thrive by making the most of the abundance of fresh water.

Keywords: Motya; Mediterranean; water management; hydraulic innovations; wells

1. INTRODUCTION

Freshwater made possible human life since Prehistory[1] on the island of Motya. The great availability of freshwater made Motya an extremely strategic land for sailors who could supply their ships. The soil is made up of a water-repellent clayish marl bedrock impenetrable by the sea water.[2] Before the arrival of the Phoenicians, the south-western area of the island appeared as a very slight slope of clayish marl, 3 m above sea level, characterized by a large depression located about 30 m from the shore.[3] Here the phreatic aquifer emerged giving life to a small pond[4] (§ 3.2) that attracted the Phoenicians sailors during their expansion across the Mediterranean.[5] In fact, during the 8th century BC, the first Phoenician settlement arose in the southern quadrant of the island (Area C South) where the oldest Phoenician warehouse, the "Building C8", was erected.[6]

The clayish marl bedrock was immediately cut, remodelled, and regularized in order to capture and collect freshwater. The phreatic aquifer was more easily accessible a few meters from the southern seashore[7] and for this reason, exploiting the properties of the local clayish marl, the Phoenicians isolated it with layers of compacted clay and dug a long series of wells, lined up in two rows along an east-west axis. They served to supply the first houses and the Building C8 and, possibly, the ships that were moored at the southern mouth of the Marsala Lagoon where the first harbour of Motya was located.

1 Nigro 2012a, 294; 2012b, 207; 2023, 62, 66.
2 The Marsala Lagoon has a salinity five times higher than the sea (Tusa 2004, 449-450).
3 Nigro - Spagnoli 2017, 6.
4 In the area of the so-called «Kothon» the remains of this first frequentation were obliterated by the next Phoenician occupation (Nigro - Spagnoli 2012, 2).
5 Nigro 2016, 359; 2020a, 98-99.
6 The Building C8 has a tripartite plan and served as a warehouse, trading place and shelter for sailors (Nigro 2013, 53-54, fig. 6; 2019a, 139).
7 Nigro 2013, 41; Nigro - Spagnoli 2017, 6-7.

ISSN 0393-0300; 2724-587X
e-ISSN 2532-5159
doi: 10.53131/VO2724-587X2024_28

2. Water management in the Island of Motya

2.1. *The first use of the wells (VIII-VII century BC)*

The first Phoenician settlement stood next to the little pond fed by three mainly springs in the Area C: the Kothon Spring (fig. 1), the Temple Spring and the Favissa 2950 Spring.[8] Between the Favissa 2950 Spring and the coast, the first Phoenician inhabitants dug eight wells aligned on two sides.[9] The wells were lined inside of small and medium-sized stones.[10] They were 2 meters tall because of the high level of groundwater[11] and they had a cylindrical section widened at the bottom.[12]

The wells of Area C South - P.1660, P.1673, P.2950, P.2927 and W.1[13] - were characterized by an effective technique of construction and coating (fig. 2).[14] Pure clay was used as a glue in the gaps between the stones while the interior of the well was covered with a clay plaster. The plaster retained its insulating prerogatives by constantly remaining wet. The diameter of the wells was about 0.60-0.80 m.[15]

In this period, there was no evidence of buckets to collect water from wells, but we can assume that the water was collected with containers made of perishable materials, such as wood or leather.

The floor was raised about 0.5 m with a layer of brown clay soil and the hole of the well was rebuilt, at the end of the first phase of use of the wells (Motya IVA_2, 800-750 BC).[16]

2.2. *The second phase of use of the wells (VI-V century BC)*

From the second half of the 6th century BC, new wells were dug inside the island, in the village of Area B. The wellheads were built in square blocks of limestone, carefully cut and mounted with dovetails joints as P.2520,[17] located in a domestic unit of the Area B, in the so-called "Squared Well House" (fig. 3). Usually, the squares wellheads were made from a single cube of stone drilled in the center. The wells had a margin detected in which was housed a cap in terracotta with a small central circular opening.[18] The diameter of the wells was about 0.60 m per side.

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8 Nigro - Spagnoli 2012, 2-3, fig. 3; Nigro 2019a, 138, fig. 3.

9 Isserlin - Du Plat Taylor 1974, 1-2, pl. XIV; Nigro - Spagnoli 2012, 34-37, figs. 13, 32; Nigro 2019a, 138, fig. 4.

10 The stones came from the Birgi river, 1 km north of the island (Nigro 2019a, 138).

11 Nigro 2010a, 8-9, figs. 5-6; 2019a, fig. 5.

12 This feature was present in the Levant as in Ugarit, W.3049, W.3051 (Calvet - Geyer 1987, 134; Matoïan - Geyer 2013, 48-62; Haydar *et al.* 2013, 456-458), in Cyprus, at Hala Sultan Tekke, F.1176, F.1552, F.7012 (Åstrom 1998, 7, 26-51, 110-128, 133, figs. 2-5, 45, 146), Enkomi, W.24 (Dikaios 1969, pl. 294:13) and Kition, W.1 (Karageorghis - Demas 1985, pl. 22:3).

13 Nigro 2019a, figs. 4-6.

14 The wells are still able to collect water from the water table when the sea recedes due to the tides (Du Plat Taylor 1964, 91-92; Nigro 2014, 27, 33, fig. 3; 2019a, 141).

15 Nigro 2019a, 142.

16 Nigro - Lisella 2004, 78-80, figs. 2-6; Nigro - Spagnoli 2012, 6-7, figs. 12-13; Nigro 2014, 11-14; 2019a, 138.

17 Nigro 2019a, fig. 10.

18 Nigro a cura di 2004, 212, fig. 3.65; Nigro 2019a, 142, fig. 9; about the cover in terracotta, Du Plat Taylor 1964, 92, fig. 12; Nigro a cura di 2004, 211; 2005, 148, pl. XIX:MD.03.339.

Above the wells an arch with a pulley was used to collect water. The buckets found near the wells,[19] dated to the 5th century BC, testify to the use of the wells during this period: this vessel was tied to the pulley and then collect water from the aquifer inside the well.[20]

The reorganization of water infrastructure and the appearance of new types of wells reflect the island's subjugation to Carthaginian influence.[21] In fact, the presence of water structures excavated within domestic units - as P.2520 and P.4616 in area B - reflects a well-organized urban planning in which the water element represented one of the pillars of urban development of Phoenician-Punic tradition. The presence of wells or cisterns within each domestic unit distinguishes the Punic cities such as Carthage or Kerkouane.[22] Another distinctive element of the Punic influence was the presence of monolithic coping and terracotta pipes that begin to be built from the end of the 6th century BC.[23] In fact, the use of terracotta pipes makes it possible to optimise the transport of water, since the material is less porous than the local sandstone.

2.3. *The cisterns*

The cisterns were the most numerous water installations, in addition to wells. The oldest cistern, P.1345,[24] has been found near the Western Fortress, and it dates to the late 7th century BC (Motya VB, 625-550 BC). Other cisterns, more recent, were found, in Area D[25] and in the Industrial Quarter.[26]

The cistern P.1345 had two phases: in the first phase, it had a circular section - 1 m of diameter - and the opening hole was lined with rectangular blocks; in the second phase - P.1347 - it had a rectangular section - 0.42 m per side - and was made by relatively thin limestone slabs; these slabs was joint in dovetails with alternating rows. On the slabs, the little holes were dug to make it possible to descend to inspect the cistern or clean it.[27]

The remaining cisterns of the city[28] had the so-called "bottle-section"; they were about 5-7 m deep, 2 m wide and had an average capacity of 70 m^3.

The cisterns were dug in the courtyards of the houses next to the walls. This position allowed to collect rainwater through the terracotta.[29] The houses had flat roofs lined with

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19 Nigro a cura di 2007, 102, pls. XXXV:MD.03.1009/107, XLI:MD.03.1019/16, LXIII: MD.03.1056/8.

20 The bucket was made by adding a transversal handle to the mouth of the common ware olla (Vecchio 2002, 262-263; Nigro 2019a, 142, fig. 11).

21 The conquest of Motya dates to the middle of the 6th century BC by Carthaginian general Malco. From this moment, the city was entirely reconstructed (Nigro 2018, 261).

22 Tang 2005, 83-85; Del Basso 2019, 2-3; Fantar 2020, 64-65. Private water management through the digging of wells inside individual dwellings has a long history, dating back to the second half of the 2nd millennium BC, as Ugarit in Syria, Enkomi and Hala Sultan Tekke in Cyprus (Dikaios 1969; Åstrom 1998; Fischer - Bürge 2018; Geyer - Matoïan 2023).

23 Several comparisons can be cited with Phoenician/Punic sites such as Carthage, Kerkouane and Nora (Tang 2005, 83; Cespa 2019, 51-53; Fantar 2020, 64-65).

24 Nigro a cura di 2011, 53, 61, 64-65, figs. 3.33-3.34; Nigro 2019a, 143, figs. 12-15.

25 P.200 (Nigro 2019a, 142).

26 Tusa 1978, 76-77, fig. 5, pl. LIX:1-2.

27 This practice was known in the Levant, as at Teleilat el-Ghassul, Kissonerga-Mylouthkia and Ugarit (Mallon - Köppel - Neuville 1934, 39; Peltenburg 2003, fig. 29; Matoïan - Geyer 2013, 48).

28 Nigro a cura di 2004; Nigro 2010a; 2019a, 142; Nigro - Spagnoli 2012, 5, fig. 10.

29 Famà - Toti - Vecchio 2002, 57-58; Nigro 2019a, 142.

plaster and the rainwater collected was conveyed to clay pipes that usually flowed into a pit inserted in the flooring of the interior courtyard of the house. This new introduction of hydraulic technique was known also in the Levant[30] during the 2nd millennium BC and was spread in the central Mediterranean through the Phoenicians since 6th century BC.[31]

The Phoenician's knowledge of hydraulics found its greatest expression in the construction of cisterns, which spread across the central Mediterranean in parallel with Carthaginian expansion.[32] However, in Motya, the most common type of water supply is the well. This preference is reasonable due to the abundance of water from the aquifer and its easy accessibility. In addition, the water table was replenished by collecting rainwater through terracotta pipes.

2.4. *The religious infrastructure*

In Motya a particular type of wells were linked to religious activity. The sacred wells were in the three main religious areas: the Tofet sanctuary (P.1 and P.2),[33] the Temple of Ba'al in the sacred area of the so-called "Kothon" (P.53)[34] and the Temple of Cappiddazzu (The Sacred Well).[35]

The three wells had two phases: during the first phase (7th century BC), they had a circular section and little stones that lined the hole; during the second one (6th century BC), the wells were built with a different section - squared, P.2[36] and Well of Cappiddazzu, and pyramid shaped, P.53 - and large limestone rectangular slabs. In the upper part and along the *corpus* of the well, the slabs were arranged in edgeways; in the bottom of the wells, the last limestone slabs were arranged in horizontal.

In the second reconstruction the sacred wells of the Tofet and the Cappiddazzu were dug in different positions: in the innermost part of the north-eastern nave of the Temple of Cappiddazzu and in the southern part of the Tophet.

The well P.53 was connected by an underground canal with the nearby obelisk, for the sacred libations and then with the Kothon.

In the middle of 6th century BC (Phase 5, Motya VI, 550-470 BC), the southern area of the island was monumentalized into a large cultic complex.[37] A circular *Temenos* enclosed the major areas of worship - The Temple of Ba'al,[38] the Temple of Astarte,[39] and the Sanctuary for the Holy Waters[40] - and the so-called Kothon.[41] The arrangement of

30 As in Ebla and Ugarit (Callot 1983, 31-35; Ascalone - Peyronel - Spreafico 2014, 249-250).
31 Fumadó-Ortega 2019, 180-181.
32 The success of the cisterns is due to their simplicity of construction (Fumadó-Ortega 2019, 180); in some cases, such as Pantelleria, the number of the cisterns of Punic period reaches the 300 examples (Schön 2019, 218-221).
33 Ciasca 1972, fig. 7; 1992, 118-119, 127; Nigro 2009a, fig. 10; 2019a, 147, fig. 16.
34 Nigro a cura di 2004, 58, 79-80; 2007, 26, figs. 12, 16; Nigro 2019a, 147.
35 Nigro 2009a, 244, 247, figs. 3, 5-6; 2019a, 147.
36 Nigro 2020b, 138-140.
37 Nigro 2018, 256-260; 2022a; 2022d.
38 Nigro 2004; 2009b, 551-552; 2009c, 703-708; 2015a, 84-93; Nigro - Spagnoli 2017, 49-53.
39 Nigro 2015b, 236-244; 2018, 269-271; 2019b; 2022b, 45-61.
40 Nigro 2019a, 149-152.
41 Nigro 2022c; 2022d.

buildings, stelae, altars, pits, votive offerings and other features within the enclosure, suggest a place of religious activity dedicated to the sacred waters.

2.4.1 The basin of the sacred Area of Kothon

In the Area of Kothon was a rectangular sacred pool used for different functions related to worship,[42] from the ablutions of the faithful and the divine simulacra to the observation of the stars.[43] The sacred pool was fed by a spring of fresh water from north, through a series of projecting blocks of limestone and by an underground channel coming from the source of the Temple of Ba'al.[44] A basic element required to understand the water systems linking the basin to the Temple was obtained by geological investigations and paleo-environmental studies in the Marsala Lagoon where Motya lies.

In antiquity, in fact, the sea level was 0.8-1 m lower, allowing fresh water, present in the underground marl strata, to erupt.[45] Moreover, geological investigations demonstrated that the sacred well in the central cult space of the Temple received fresh water from the same source.[46] The Kothon and the Temple were thus connected by an underground system, which can be easily related to classic ideological conceptions that the Phoenicians held. The sacred pool and the sacred well were both communicating directly with the world of underground waters.

3. Innovations in hydraulic management

3.1. *The construction of the wells*

An innovation in the hydraulic management and construction of the wells is the presence of terracotta lids (§ 2.2). They were used both to oppose the evaporation of water, in particular during the summer, and to avoid the fall of foreign bodies, such as animals, that could pollute the well.[47]

At the bottom of the wells, the last limestone slabs were arranged in horizontal. The slabs dug the marl soil and allowed to better absorb the groundwater imprisoned in the clay layer, making it flow into the well due to the porosity of the stone.

Moreover, different construction techniques are used for domestic and sacred wells. In the first case, they were round in cross section, lined usually with little or medium size stone; the coping was raised several cm; in the second case, they were round in squared section, lined by a unique block of limestone or four rectangular slabs. Unlike the domestic wells, the copings of sacred wells were at floor level to facilitate the sacred ablutions. In

[42] The pool had a purifying function and a symbolic reference to the lower and chthonic world of Ba'al. Moreover, the god for his quality as ruler of the waters had also to guarantee protection to the sailors. The figure of Astarte was linked to astral aspects (Nigro - Spagnoli 2012, 50, 57; Spagnoli 2013, 157-160; 2014, 95-97; Nigro 2015b, 240-241; 2019b).

[43] Nigro 2010b; 2019a, 149; 2022d.

[44] Nigro 2014, 22-23.

[45] Nigro - Spagnoli 2012, 7.

[46] Nigro 2009b, 552, figs. 306-307, 319.

[47] Du Plat Taylor 1964, 92, fig. 12; Nigro a cura di 2004, 211; 2005, 148, pl. XIX:MD.03.339; Nigro 2019a, 142, fig. 10.

addition to the specific purposes linked with the sacred contexts, these technical differences marked the two kinds of well.

3.2. *The Kothon springs*

The earliest inhabitants of Motya took advantage of the presence of freshwater that naturally emerged in the southern part of the island, thanks to the presence of three natural springs located to the north, east and southeast of the ancient pond (fig. 4). In fact, this important resource has allowed the birth of a flourishing agriculture and horticulture. Later, the abundance of water was exploited by early Oriental peoples and was instrumental in the establishment of the first Phoenician settlement (Motya IVA$_2$-V, 800-550 BC).[48] The pond was regularized in order to capture and collect freshwater and irrigate the surrounding area. The increase of population due to a continuous arrival of people from the Levant has necessitated greater attention to water management.[49] Indeed, the first interventions carried out by the new population are the regularization of water sources around the pond,[50] which was progressively transformed into a pool, the excavation of a series of wells (§ 2.1) catching freshwaters from the phreatic aquifer that was only 2 meters deep. The first artificial basin was built at the end of 8th century BC.[51] It was bounded by large blocks of sandstone cut in a roughly regular pattern with a thickness of about 0.52 m and a length of 1.04 m.

Only a section of the eastern wall remains visible today, incorporated in the eastern quay of the later Kothon built during the 6th century BC. In this period the pond was regularized as sacred pool (§ 2.4.1).

4. Final remarks

The freshwater was a decisive resource in Motya for the birth and development of the prehistoric settlement and the Phoenician city. The water collected in the south-western sector of the Island of Motya was used both for supplying the inhabitants and sailors, and for the worship activities in the Temple of the Kothon and in the installations connected to it. The emerging freshwater aquifer in the whole south-western area of Motya was probably the most significant element of the first Phoenician settlement in the Sicilian Island and was partially regimented already during the 8th century BC. Later, a complete reorganization of the system of springs and wells realized at the time of the first Motya took place with the great reconstruction of the city and the sacred area of the mid-6th century BC. From this moment, the management of water infrastructure has been restructured due to the Carthaginian hegemony, resulting in a more widespread administration of water resources.

The presence of traditional and innovative elements in the construction of water systems testify the attention and the expertise of Phoenicians in the management of waters.

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48 Indeed, the first Phoenician houses were built to the east of the natural springs, this made it easier to collect water, Nigro - Spagnoli 2012, 1-2; Nigro 2020a, 99-101.

49 It is likely that the population has reached about 1,500 inhabitants in the time span of about a century, 800-700 BC (Nigro 2022e, 344).

50 A layer of clay soil was extracted from the bottom of the original pond to raise the floor around the pool about 0.5 meters (Nigro 2019a, 138).

51 Nigro 2019a, 141.

The Phoenicians shared and transmitted a broad tradition linked to springs, water and related cult installations,[52] but at the same time the arrangement of the Kothon and the findings associated with them also suggest an astronomical function (§ 3.2).

On the one hand the use of certain practices, such as dovetails joints, collection of water through the vertical pipe from the roof and use of the wells also as cisterns, on the other the use to cover the well, to put the vertical limestone slabs in the base to optimize the water collection (§ 3.1), and the use of the Kothon as astronomical observatory, suggest that the Phoenicians could combine previous eastern knowledge of water management with innovative elements.

Finally, the management of water structures has been a component of the broader framework of sharing materials, techniques, and ideas that spread throughout the Mediterranean Punic from the 6th century BC.

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[52] Compare in the East with the "Ma'abed" of Amrit (Mingazzini 1968, 105-112; Dunand - Saliby 1985).

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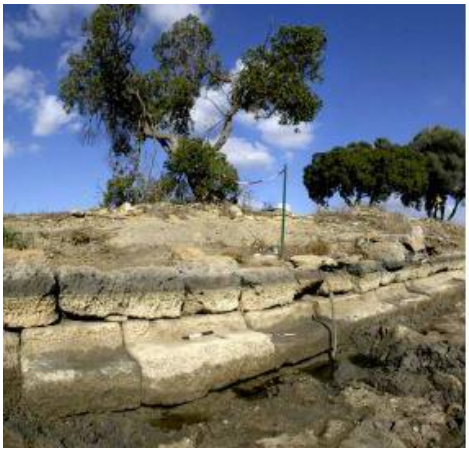

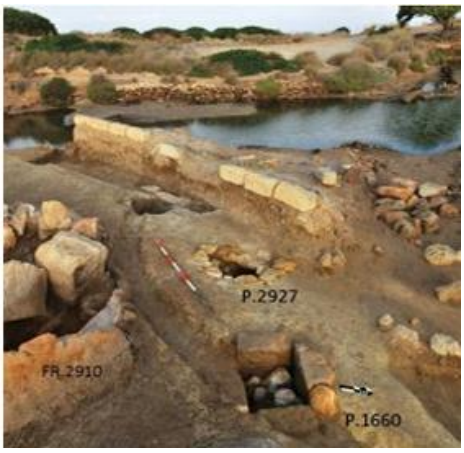

Figs. 1-2 - On the left the Spring of the Kothon captured through building blocks on the northern side of Kothon; on the right Wells P.2927 and P.1660 on the southern slope of the Kothon belonged to the first Phoenician settlement in Motya (Nigro - Spagnoli 2012, fig. 5; Nigro 2019a, fig. 6).

Fig. 3 - Wells with monolithic - P.2520 and P.4616 - coping from Area B (Nigro 2019a, fig. 10).

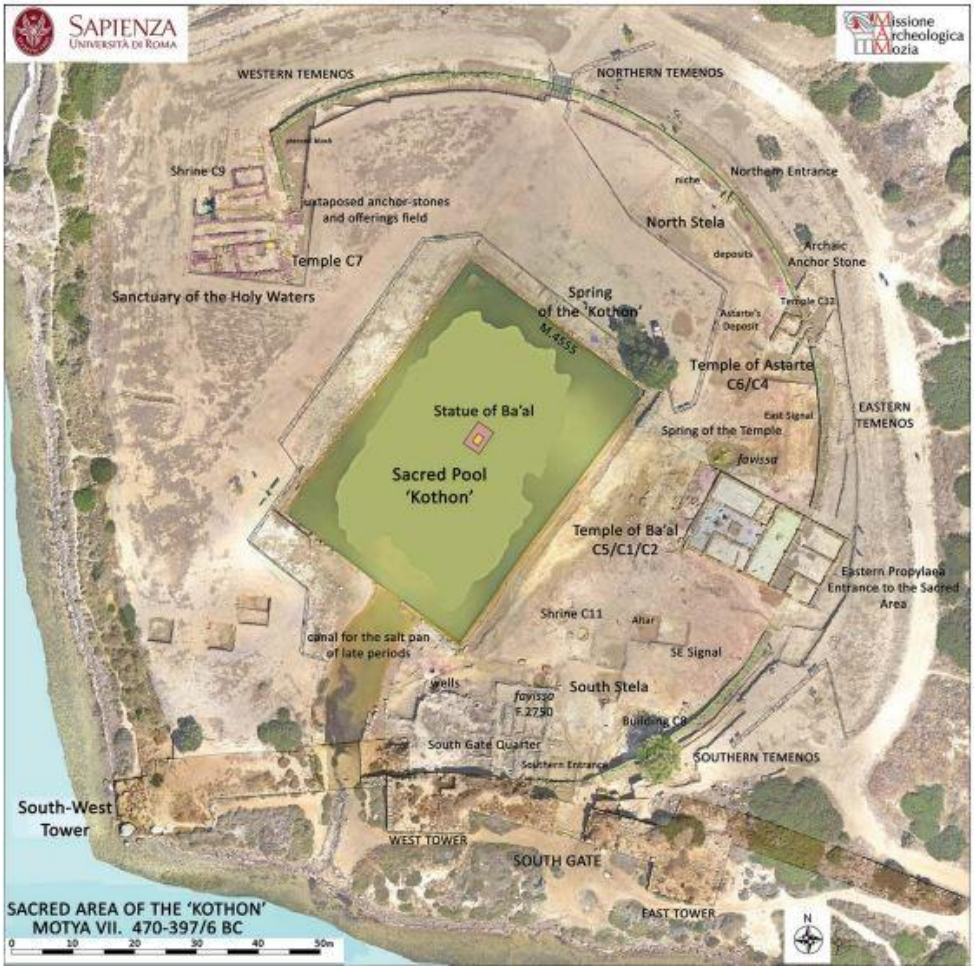

Fig. 4 - Aerial view of the sacred area of Kothon (Nigro 2022c, fig. 2).