IKŚiO PAN

Études et Travaux XXXV (2022), 163–187

Water and Fire – The History of a Mound of Ash Water Management in Hellenistic Berenike, Its Environmental and Logistical Setting

Marek A. Woźniak, Szymon Popławski

Abstract: Archaeological work since 2014 in the Hellenistic areas of Berenike, a key port on Egypt's Red Sea coast, founded by Ptolemy II Philadelphus in *c*. 275 BC, has brought extensive evidence of water-related structures: a rock-cut well located inside a rebuilt early-Hellenistic gate and a nearby cistern with an associated rainwater-collection system, that has changed the way in which the sources and uses of water in Hellenistic Berenike is understood today. The research started with the excavation of an ash mound, a characteristic landmark in the western part of the site, which is now believed to be the rubbish dump from the furnace that heated a Hellenistic bathhouse. At this stage in the research, it can be argued that Hellenistic Berenike had sufficient water available on site not only for drinking (hence potable), and agricultural and industrial uses, but also for public bathing. This article summarises the current state of research, presenting recent discoveries of a Hellenistic date at the site within their archaeological, architectural and environmental contexts.

Keywords: Hellenistic bath, water supply, Red Sea, Graeco-Roman harbour cities, the ancient Spice Route, Hellenistic Egypt

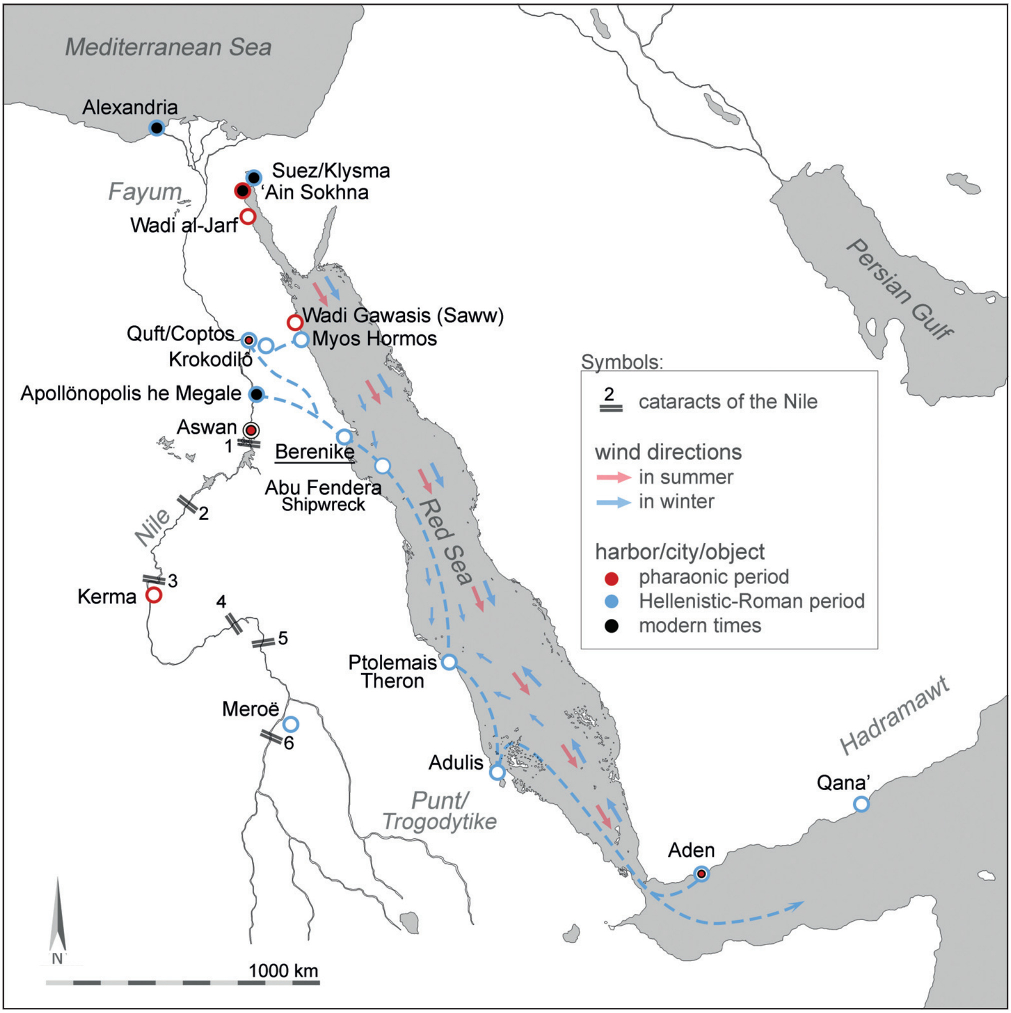
Marek A. Woźniak, Institute of Mediterranean and Oriental Cultures, Polish Academy of Sciences, Warsaw; *mawozniak@iksio.pan.pl*; 0000-0003-2450-0192

Szymon Popławski, Wrocław University of Science and Technology, Wrocław; *szymon.poplawski@wp.pl*

The archaeological excavations at the Berenike site, carried out, intermittently, since 1994, have contributed to uncovering the remains of one of the most important port centres of the Red Sea and Indian Ocean region. They have also made it possible to study the only material remains of a Hellenistic port city discovered so far anywhere in East Africa verifying the scant historical information concerning Ptolemaic activity in this extremely important region.

Berenike Trogodytika was established sometime at the end of the first quarter of the third century BC, as one of the first and most important ports built by the order of Ptolemy II for

DOI: 10.12775/EtudTrav.35.008

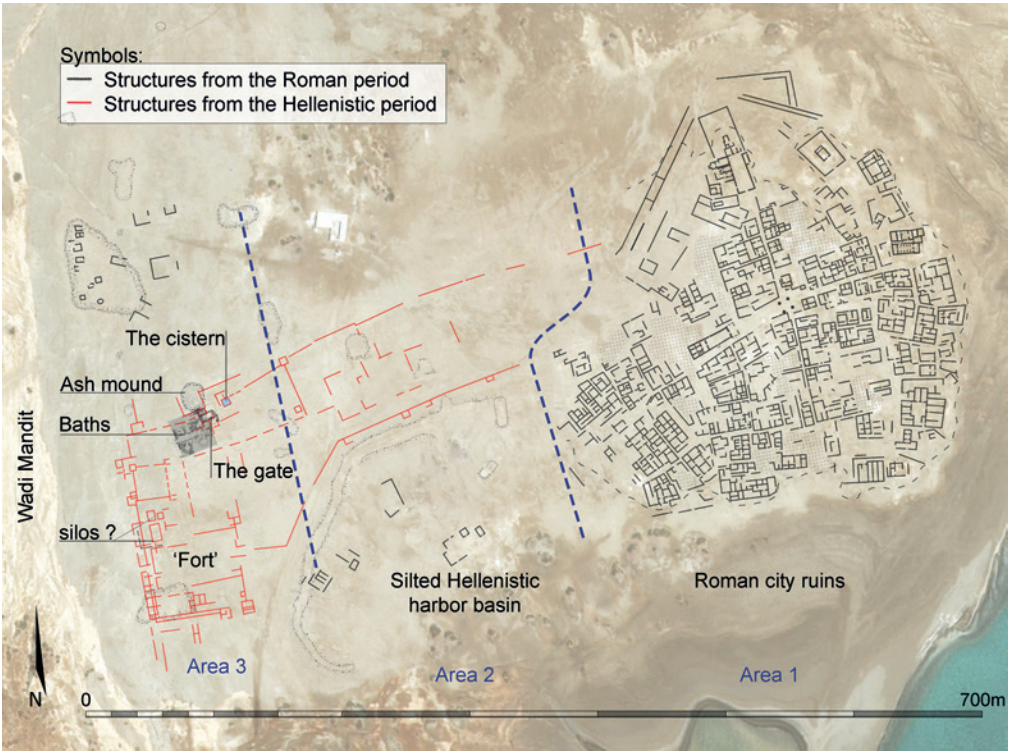


1. Localisation of the Berenike in the Red Sea and Eastern Desert area (Drawing: S. Popławski, M. Woźniak).

the exploration of East Africa. The project of building a chain of cities/bases located along the western coast of the Red Sea clearly referred to Pharaonic expeditions to the legendary land of Punt.[1] It also represented a continuation of the Saite and Achaemenid endeavours to establish a permanent, secure communication route to access the riches of the south.

Written sources, supported by archaeological finds, have placed the handling of war elephant imports for the Ptolemaic army as one of the most important operations carried out at Hellenistic Berenike.[2] It was suited for this due to its location. The pattern of winds that

[1] Bard, Fattovich, Ward 2007; Bard, Fattovich (Eds) 2007; Bard, Fattovich 2010; Tallet 2016; Taterka 2020.
[2] Wilcken 1963: 452; Sidebotham, Wendrich 1998: 86; Woźniak *et al.* 2021: 252–255.



2. Satellite image of Berenike overlain with a plan of the site (Retrieved from Google Earth, status as of December 2019; processing: S. Popławski, M. Woźniak).

cyclically blow around the Red Sea and the passages through the mountains separating the Red Sea coast from the Nile Valley[3] (**Fig. 1**) turned Berenike into the main seaport and, most probably, a repair yard for the so-called *elephantegoi*, the heaviest ships operating in the southern part of the sea route, specifically designed to carry elephants.[4] This would not have been possible without significant infrastructure, sufficient to sustain a population of several hundred people operating in this capacity. Yet little on the surface of the site suggested this kind of urban and commercial complexity.

Preliminary surveys showed that a zone of Hellenistic material extended to the west of the ruins from the Roman period, as far as the Wadi Mandit trough (approximately 400m) marking the western edge of the site (**Fig. 2**). However, almost no permanent structures were identified here during the field survey.[5] One of the site landmarks noted in preliminary

---

[3] Woźniak *et al.* 2021: 251–252; Woźniak 2022.

[4] The *elephantegoi* are mentioned *expressis verbis* in two written sources – a papyrus discovered in Fayum dated 224 BC (see: Wilcken 1963: 452) and Agatharchides of Knidos (5.85). See also Diodorus Siculus (3.40.4); Burstein 1989: 141 and n. 3; Sidebotham 2011: 48–49; Woźniak *et al.* 2021: 251–252, n. 32, 255.

[5] Aldsworth, Sidebotham, Wendrich 1995: 18; Sidebotham 1998: 101.

surveys was a mound of ash (**Fig. 2**) mixed with potsherds and rubble, measuring about 3m in height and 11m in diameter at its base. Its location, on otherwise flat and empty terrain in the western part of the site, puzzled archaeologists.[6] Excavations in 1996 cut through the south-eastern quarter of this mound and revealed numerous thin layers of ash, anhydrite rubble, separated by layers of windblown sand. The archaeological material consisted of fragments of clay storage jars from the early Hellenistic period.[7] The only structure was a wall made of poor quality, porous stone, 0.55m wide, standing to a height of 0.8–1m.[8] It bordered the ash mound on the south and east. The discovery of several fragments of fired bricks suggested an initial interpretation of the mound as refuse from a brick kiln.[9] Yet, excavations identified no structure capable of withstanding the heat related to making bricks. There was no other excavation in this area until 2014, during and after which additional surveys and four excavation seasons in 2014–2015 and 2018–2019 south and south-east of the mound were undertaken.[10]

This paper discusses the current state of research on Hellenistic water-related structures discovered in this part of Berenike, within their archaeological, architectural and environmental contexts.

TOPOGRAPHY OF THE SITE

Until 1999, archaeological work at Berenike concentrated only on the eastern part of the site, where the remains of a Roman-period town were intensively studied (**Fig. 2**; Area 1).[11] The impetus to return to the western part was provided by a geophysical survey (magnetic prospecting) carried out in 1999 in what appeared to be a zone of the site mostly devoid of permanent structures. This survey revealed a series of small rooms and structures built almost on the very eastern edge of Wadi Mandit (**Fig. 2**; western part of Area 3).[12]

A series of archaeological trenches dug out here in 2000–2001 and 2010 completely confirmed these conclusions. Fragments of walls of varying thickness (from 0.4m to about 1m wide), made of anhydrite blocks and chippings and forming a series of rooms (measuring about 6 x 7m) built in a row, from north to south, were uncovered here. Parts of two structures built less carefully, of only small fragments of anhydrite, were also discovered. In the first phase of their functioning, these structures were most probably a kind of silo for storing loose, dry materials (grain?) and were later turned into rubbish dumps.[13]

---

[6] Sidebotham 1998: 11, 101.

[7] Tomber 1998: 163–169.

[8] Woźniak 2017: 47–48.

[9] Sidebotham 1998: 101–109.

[10] Delayed permits in 2016 and 2017 made excavations impossible in these seasons. Woźniak 2017; 2019; Woźniak *et al.* 2021; Woźniak, Harrell 2021.

[11] Sidebotham 1995b; 1996; 1998; 1999; 2000.

[12] Herbich 2007.

[13] Sidebotham 2007: 31–44; Woźniak, Rądkowska 2014: 509–514.

The nature of the archaeological material (pottery, ash, lead fragments, pieces of slag from metal smelting, and dozens of copper and iron nails) caused the entire western part of the site to be called a 'Hellenistic industrial area' in the early reports.[14]

Thorough analyses of the magnetic maps led to the conclusion in 2012 that the sequence of rooms and structures investigated in this zone constitutes the western part of a single, multi-phase, fortified building of an industrial-warehouse character. Its massive outer walls, which had (at least in the northern part) square towers, its rectangular plan, the austerity of its architecture and its large size (at least 150 x 80m) all contributed to it being called a fort at the time.[15]

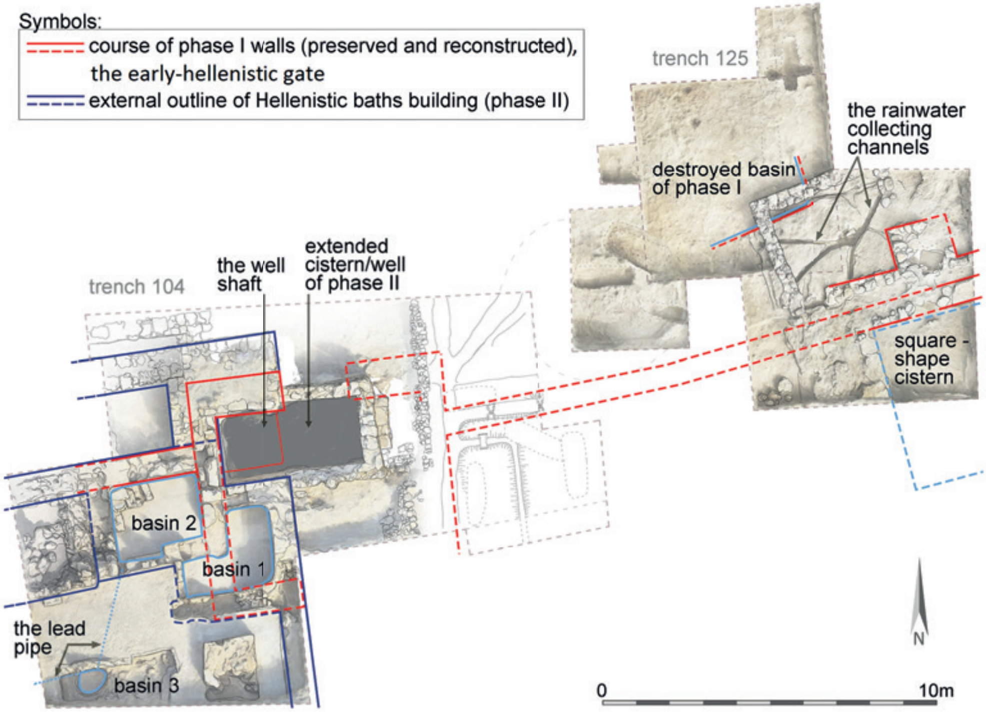
The Berenike site is now divided into three areas (**Fig. 2**). Looking from the east, Area 1 consists of the densely overbuilt Roman and post-Roman city. Area 2, located in the central part of the site, north of the silted Hellenistic and early Roman harbour basin, is made up of a large early Roman-period rubbish dump in the north-east and a largely Hellenistic one in the southern and eastern parts, but both of them overlying unidentified structures (perhaps houses or workshops) from the Ptolemaic period. Area 3 encompasses a huge Ptolemaic fort building, together with some unidentified structures (also from the Hellenistic period) extending further north up to the post-Roman cemetery in the north-west.

THE WELL IN THE HELLENISTIC GATE, ITS INSTALLATIONS AND THE GEOLOGICAL STRUCTURES OF THE BERENIKE PLAIN

In 2014, excavations in the vicinity of the mound of ash, located north of the fort, but in a zone functionally related to it, uncovered the remains of a small gate from the early Hellenistic period (**Fig. 3**).[16] In the first phase of its functioning, the gate was housed in a single, square tower measuring *c.* 8 x 8m. The walls were 1–1.1m thick, built of well-worked and locally quarried anhydrite blocks. The tower was provided with two gateways, in the north and south walls, and one, square inner chamber. The massive walls were built without foundations directly on top of bedrock. Only the north-western quarter of the tower remains today.[17]

The gate in itself is an exceptional discovery, as no parallel of this date exists anywhere along the Red Sea coast. However, like the defences of which it was part, it functioned for a very short time at the end of the first half of the third century BC.[18] In about 250–240 BC the western half of the structure was dismantled and its eastern half, together with structures related to the storage and distribution of water,[19] was incorporated into a new, large building (**Fig. 3**, phase II), measuring *c.* 20m on a N–S axis and 18m on an E–W one, later identified as bathhouse (see below).

[14] Sidebotham 2007: 30.
[15] Woźniak, Rądkowska 2014: 513–514.
[16] Woźniak *et al.* 2021: 268–273; Woźniak, Harrell 2021: 354–359.
[17] Woźniak *et al.* 2021: 268–273; Woźniak, Harrell 2021: 354–359.
[18] Woźniak, Harrell 2021: 354–360.
[19] Woźniak *et al.* 2021; Woźniak, Harrell 2021.



3. The gate area and its water-related structures from phase I and II (Drawing: S. Popławski, M. Woźniak).

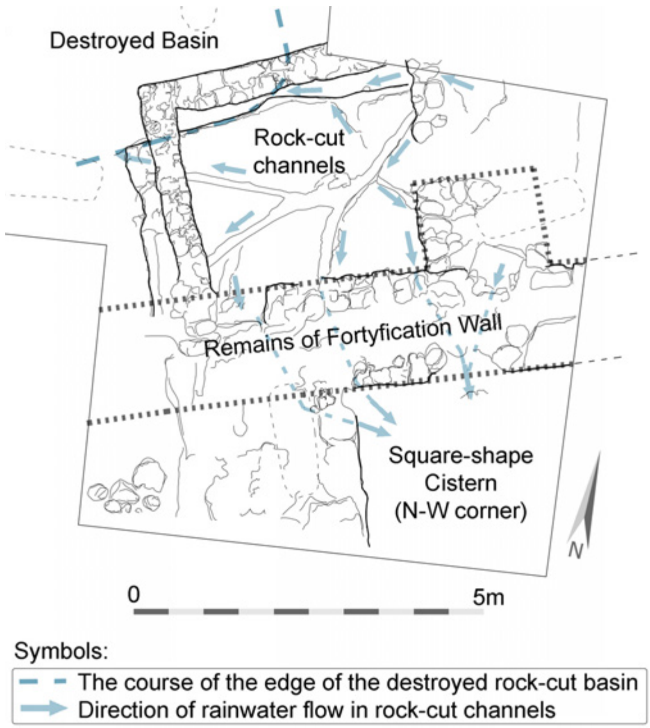
The combination of excavation results and geophysical map analysis revealed that the water systems existed in the gate area and occupied at least two buildings. The first, larger one (the north-eastern part of which consisted of the remains of the former gate tower) in the phase II housed two large, almost square basins lined with reddish hydraulic mortar (for Basin 3 see below) and a deep cistern cut into bedrock. The cistern measured 2 x 3.9m, was 3.7–3.9m deep[20] and had been built in the northern part of the inner chamber of the former gate. A second, larger and square-shaped cistern lying approximately 15m east of the remains of the gate,[21] in a separate, smaller building, clearly traced on the magnetic map of the site, is estimated at about 5 x 5m (**Fig. 3**).

North and west of this second cistern was a network of narrow channels cut into the bedrock surface (**Fig. 4**). Their apparent function was to collect rainwater and channel it into the cistern (passing through the walls surrounding the reservoir).[22] However, some

[20] Woźniak *et al.* 2021: 269.

[21] Zych *et al.* 2016: 323–325; Woźniak 2017: 57; Woźniak *et al.* 2021: 273.

[22] A well-preserved coin of Ptolemy II (yet unpublished) was discovered under one of the blocks of the lowest course of the wall erected on the northern edge of the cistern.



4. The square-shape cistern and rainwater channels (Drawing: S. Popławski, M. Woźniak).

of them, in the northern part of channelled area, also ran northward where excavations exposed the destroyed remains of a *c.* 0.40m-deep rock-cut basin.[23] The entire channels system was designed so that when the basin, possibly even more than one,[24] overflowed, the excess water also from the northern part of the channelled area streamed into the cistern.

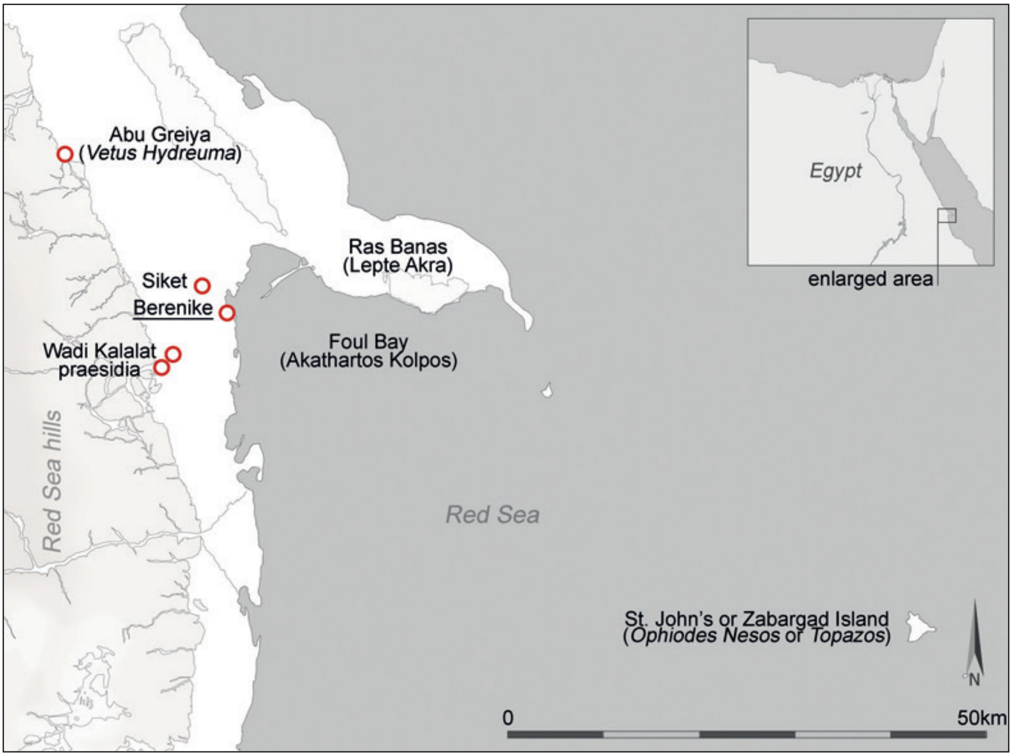
In phase I (contemporary with phase I of the gate), this basin may have collected water for the area north of the later dismantled defence wall, which ran along the northern edge of the square-shape cistern. Fragments of this wall, preserved after reconstruction and in phase II, still formed one of the internal walls of the building that housed it (**Fig. 4**).

After demolition of the fortifications and structures of phase I, around 250–240 bc, which occurred simultaneously with the removal of the eastern part of the gate, a separate water reservoir for the area north of the dismantled ramparts was no longer necessary. Levelling works for phase II (probably subphase IIa) in the eastern part of the former gate, which lowered the bedrock surface in this area by about 0.4m, removed practically all evidence of this early water system.

---

23 Woźniak *et al.* 2021: 273, Fig. 20.

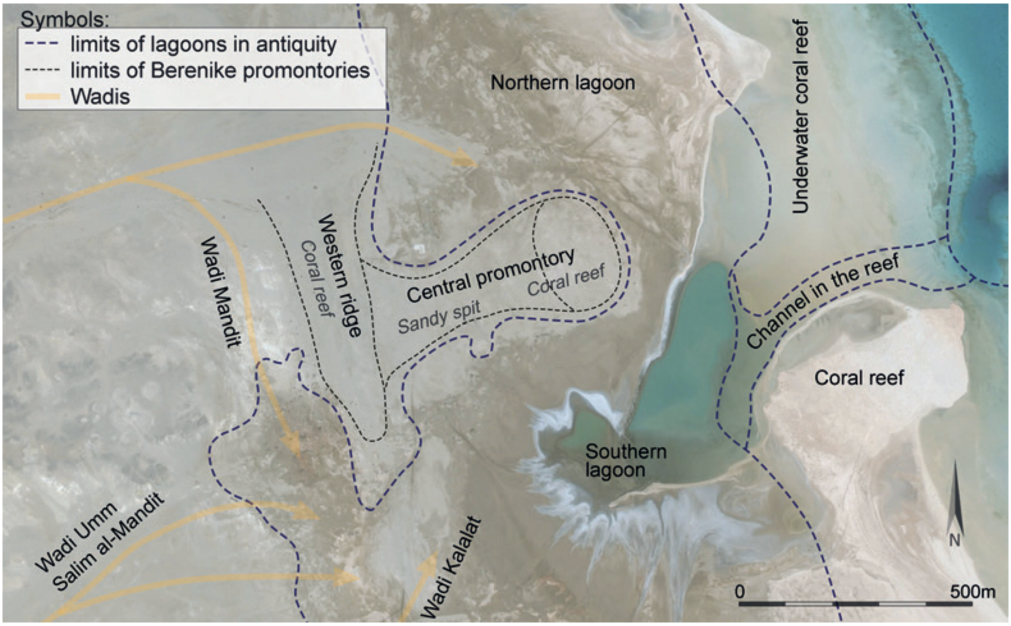
24 The layout of the channels and the direction of the flow of the water they were transporting, suggests that to the north and north-west of the square cistern there could have been more than one basin, which unfortunately did not survive the reconstruction in phase II.



5. Berenike and its environs with localisation of the *hydreuma* at Siket, Wadi Kalalat and Abu Greiya (Drawing: S. Popławski, M. Woźniak).

The archaeological evidence for a water-collection system in Berenike prompted a reassessment of ideas on how the Hellenistic city could have been supplied with water. Information on Roman Berenike, mainly from ostraca discovered at the site, had led researchers to assume that water was supplied to the city from wells dug further west of Berenike, in the wadis and at the foot of mountains. Such a system functioned in the Roman period with the wells located in the fortified *praesidia*, e.g. in Wadi Kalalat (south-west of Berenike), Siket (west north-west of Berenike), and possibly also Wadi Abu Greiya (located further north-west of the city; **Fig. 5**).[25] It was believed that the inflow of saline water – the city of Roman times lay atop a round, fossilised reef terrace, connected by a sandy spit with a vast plateau extending to the west, with sea lagoons on the north, east and south (**Fig. 6**)[26] – would have made digging wells and cutting deeper cisterns unfeasible. The fact that Hellenistic Berenike reached much further west than its Roman successor (**Fig. 2**)[27] places at least a quarter of its area on the edge of a substantial plateau of sedimentary rock,

[25] Sidebotham 1995a: 85–93; 2000: 355–365; Sidebotham, Barnard 2000; Sidebotham 2011: 99–109.
[26] Harrell 2019.
[27] Woźniak *et al.* 2021: 252–253.

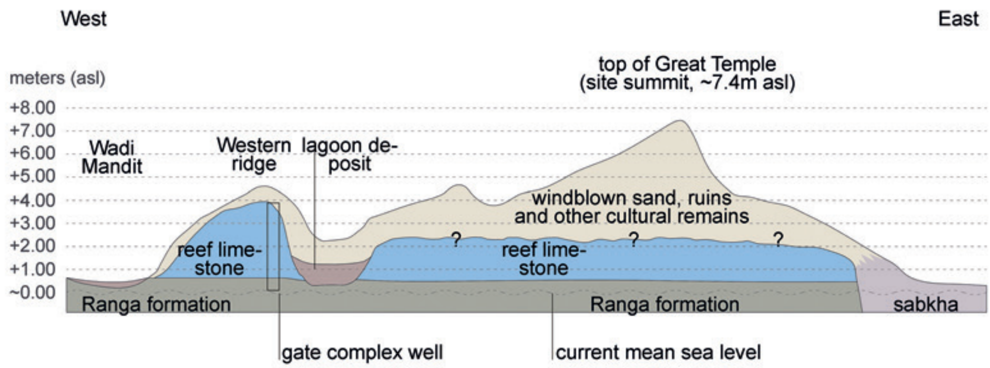


6. The Berenike site and its geological features (Retrieved from Google Earth, status as of December 2019; based on: Harrell 2019; processing: M. Woźniak, S. Popławski).

on a promontory called the Western ridge, bounded on the west by the shallow channel of Wadi Mandit, and only on the south and east by a lagoon (**Fig. 6**). Geological research has demonstrated that the Western ridge is a hard, approximately 3m-thick, impermeable layer of limestone conglomerate consisting of crushed coral material mixed with calcite and gypsum evaporites.[28] Underlying it are several meter thick layers of the Ranga formation (**Fig. 7**), which forms the bedrock of the entire plain stretching west from Berenike to the foot of the mountains.[29] The Ranga sands include the aquifer transporting the water flowing from the mountains west of Berenike and are fed by the rainfall on the Berenike plain itself. Water from the heaviest rains, which now fall sporadically mainly in October and November, also flows quickly down the shallow wadis, carving the surface of the plain and washing out the gullies into the muddy banks of the lagoon. The amount of rainwater in the aquifer determines the level of the water table and its quality. More precipitation means less dissolved salts and other minerals in the aquifer.

The destroyed basin/s of phase I described above were probably filled by torrential rains in the late autumn and early winter. In the rainy months they would have been constantly full of water because temperatures and evaporation rates were low, and rainfall was frequent

[28] Harrell 2019.
[29] Klitzsch *et al.* 1987; Said 1990: 354; Harrell 1996: 99, 101.

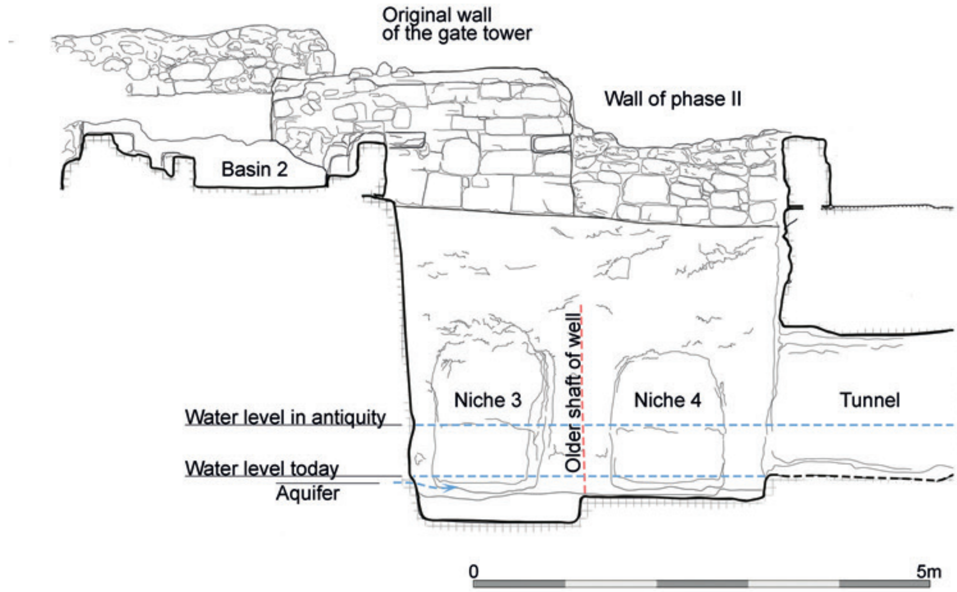


7. East–west cross-section of Berenike's topography, looking north (Drawing: S. Popławski; based on: Harrell 2019).

and heavy at that time. There is evidence for this in a bunch of early Hellenistic buildings at Berenike and at some forts and stations located on routes leading to the Nile valley, some of which have preserved low walls and clay slopes protecting the structures against flooding.[30] Rainwater from the pool/s around the square cistern and from the cistern itself was of high quality and contained fewer dissolved minerals than water from most wells in the wadis west of Berenike, which made it better suited for drinking. Therefore, it is likely that it would have been used for watering animals and may also have supplied water to the caravans passing through Berenike.

More surprising than the discovery of above-ground water installations was what excavations documented in the interior of the gate. Further excavations in 2018 demonstrated that the 3.7–3.9m-deep gate chamber was not a traditional cistern (as was supposed earlier), but that it was actually a combination of cistern and well.[31] The original shaft of a small well from phase I, located only in the north-western corner of the gate tower's chamber (which is why this part of the building remained unchanged during all subsequent reconstructions) was expanded towards the east in phase IIa, and more than doubled in size then (**Figs 3, 8**). The purpose of this enlargement was undoubtedly to collect a larger quantity of water ready for immediate use, regardless of the aquifer's yield, which could have been limited in the dryer parts of the year or season. The dismantling of the eastern part of the gate in phase II ensured better access to the water also from the east. After the first enlargement there was also another modification (phase IIb) of the well/cistern chamber: the cutting of four large niches (about 1.2m wide and 1–1.2m long), two in the northern and two in the southern side.[32] These niches were probably meant to increase the immediately available water supply. The enlarged part of the cistern was slightly shallower than the original

[30] Woźniak *et al.* 2021: 268; Sidebotham, Gates-Foster (Eds) 2019: 224.
[31] Woźniak 2019a: 249–250.
[32] Woźniak *et al.* 2021: 269.



8. A cross-section through the well/cistern chamber looking north; two of the four rock-cut niches are visible (Drawing: S. Popławski, M. Woźniak).

well shaft, had a hard bottom and did not cut through the aquifer (**Fig. 8**). The aquifer appears to drop eastward towards the sea, for this reason the eastern portion of the well/cistern appears to be too shallow to intersect it in this area. After pumping out the water, it was observed that water flowed only from the western side of the chamber, where the original small well shaft (phase I) had cut about 0.6m into the geological Ranga formation (sands and gravels divided by thin, hard layers of gypsum/anhydrite), which – collecting groundwater like a sponge – constituted an aquifer (**Fig. 7**). This was sufficient to flood (even today) the entire bottom of the eastern part of the chamber with water about 0.40m deep. In the deeper, western part of the chamber, where the bottom of the original shaft is lower, the water is approximately 0.7m deep.

The top of the aquifer, exposed in the western part of the well, is about 0.5m asl, and slightly below the water table in the well.[33] Considering that the less dense freshwater floats above the seawater, the minimal effect of seawater intrusion on water quality in the aquifer could be well explained. Though slightly saline due to the leaching of salts and minerals contained in the sands of the Ranga formation, experiments have shown that the well water can today be used for bathing and washing clothes. According to local Bedouins, animals – and, for brief periods, humans – may also consume it. Such was the case in antiquity when the water may have been even less brackish.

[33] Woźniak *et al.* 2021: 270, Fig. 16.

The geological and hydrological structure described above allowed Ptolemaic builders to apply solutions common in the classical and Hellenistic world.[34] It is difficult to imagine that a fortified port and city, under supervision of the Ptolemaic military in the early Hellenistic period,[35] would have relied on a basic resource as water being brought in from a distant sources, located kilometres away.[36] Only in the western part of the site was it possible to obtain both potable water (e.g. from rains, which could be stored in large cisterns cut into the bedrock) and 'technical' water (from the well) for domestic, agricultural and intensive industrial use. Thus, the only known well, all cisterns, and only water distribution installation discovered so far at Berenike date from the Hellenistic period and have been documented only in the western part of the site.[37] Furthermore, such installations are completely unknown from the much better studied Roman city, which may be indication of water in later times being in short supply, having to be brought to the city by caravans (supervised by the army), perhaps even paid for, carefully rationed and distributed.

In the early Hellenistic period, there were, likely, other complexes of cisterns and wells similar to those discovered near the rebuilt Hellenistic gate. Excavations recorded parts of another cistern cut into bedrock in the courtyard of the fort to the east of silos (**Fig. 2**),[38] not connected to the well and cisterns described above. Therefore, it had to be supplied with water from another source somewhere in the vicinity, in the fort's courtyard, or rainwater collected and stored nearby. Geophysical surveys here revealed the presence of several structures with square or rectangular outlines.[39] Two of them were probably silos for storing commodities such as grain,[40] one was the above-mentioned cistern, two or three others remain unidentified.

LUXURY OR NORMALITY: A HELLENISTIC-STYLE BATHHOUSE IN BERENIKE

The widespread availability and surprisingly large supply of water in early Hellenistic Berenike is best illustrated by new discoveries in 2022, which ultimately revealed that the described structures related to water collection, storage and distribution were part of

[34] Grewe 2008: 322–324; Wilson 2008: 288; Angelakis *et al.* 2016.

[35] Written sources, e.g. Strabo (16.4.5; 16.4.7), mentions the *strategoi* Satyros and Eumedes as the founders of Berenike and Ptolemais Theron. For *strategoi* Lichas and Charimortos as the commanders of hunting and exploration expeditions to the south of Red Sea region, see: Fraser 1972: 173–184, 308, 370–374; for *strategoi* involved in elephant hunting see also: Peremans, van't Dack 1952: nos 4419–4428.

[36] There is no indication that the wells at the mouth of Wadi Kalalat were functioning as early as the Hellenistic period. The same is true of the *hydreuma* at Siket. The only site associated with the extraction of water from the sands at the mouth of the wadi, functioning in the Ptolemaic period, can be a small fort at the mouth of Wadi Abu Greiya (*Vetus Hydreuma*). However, it is located more than 25km from Berenike.

[37] Woźniak *et al.* 2021: 268–276.

[38] Sidebotham 2007: 34.

[39] Herbich 2007: 23–25.

[40] Woźniak *et al.* 2021: 256–257.

a Hellenistic-style, public bathhouse, the largest of the three currently known from the entire Eastern Desert[41] and the most southerly of all known buildings of this type.

The results of the 2018 excavations already suggested that the exposed part of the building, which incorporated a gate with the cistern/well, was only a small part of it. Works in season 2022 revealed that the building in Berenike contains almost all structures typical for the Hellenistic public bathhouse,[42] i.e.: two *tholoi*, a wide Main Hall, corridors, a relaxation room with at least one bathtub for hot bathing, a technical area consisting of a system of basins and cistern/well organizing the water supply and finally presumed furnace area, where water would have been heated for use by the bathers.

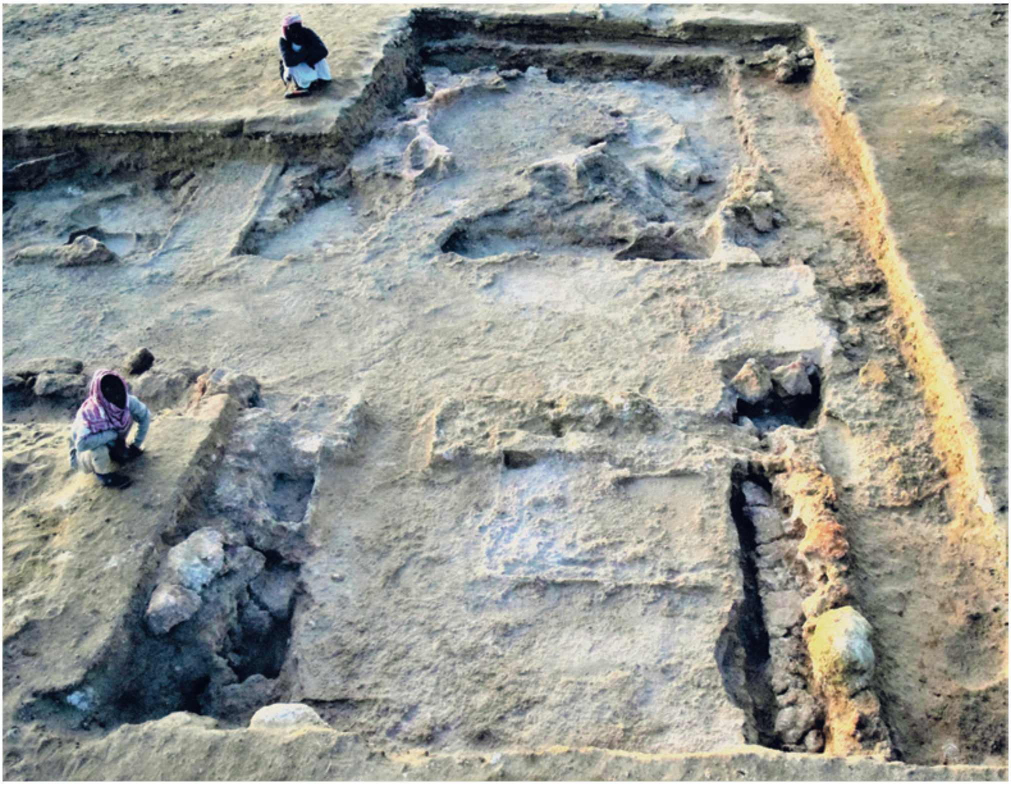
Tholoi

In the south-western and southern part of researched area excavations revealed one complete circular room with fragmentary hip-bathtubs (**Fig. 9)** and a fragment of another construction of this kind. Both rooms can be interpreted as *tholoi*, the most characteristic and easily recognisable structure of Hellenistic-style baths. The hip-bathtubs of each *tholos* are arranged in a circle, with the lower front ends facing the central space of the room and the higher side walls touching each other. They were designed for individual bathing with the bather sitting in such a tub and using a small vessel to pour water over himself. The two *tholoi* discovered at Berenike were built as separate constructions, housed in a massive, square-shape construction, measuring *c.* 5.60m on the N–S axis and 5.70m on the E–W one (**Figs 9**–**10**). They were of similar size, although only the western one has been fully excavated so far. There was at least one entrance in each *tholos*, with a diagonal passage running between the bathtubs towards the Main Hall located to the north. A semi-circular basin used from the side of the Main Hall was embedded to the right of the entrance to each of the rooms, in the north-eastern corner of each *tholos* housing. The western basin (Basin 4) measured 1.10 x 0.70m, while the eastern one (Basin 3) was 0.90 x 0.80m in size. Lead pipe, 3.60m long and 8cm in diameter, running under the floor, joined the basins to the main tank (Basin 2), which abutted the well.

The inner diameter of the *tholoi* (including the hip-bathtubs), based on the dimensions of the western tholos, was 4.50m, while the central space was 2.40m in diameter. There were probably fifteen bathtubs in each of the rooms. These were oval-shaped features, about 0.90m long and 0.45m wide at their preserved front. Neither the seat shape, probably made of a single, flat block of anhydrite covered by a thin layer of hydraulic mortar, nor the form of the separation of the hip-bathtubs, could be determined based on the extant remains. The sides of the hip-bathtubs comprised anhydrite/gypsum slabs 0.08–0.10m thick, covered with reddish hydraulic mortar, which also gave the overall shape to these features.

[41] In the Eastern Desert, baths dating to the Ptolemaic period (smaller and devoid of *tholoi*) were discovered in a fort at the Bir-Samut site (Brun, Faucher, Redon 2017) and at a Ptolemaic mining settlement in Ghozza, about 300km in a straight line north-west of Berenike and about 100km east of Qena (Redon 2022).

[42] Fournet, Redon 2017a.

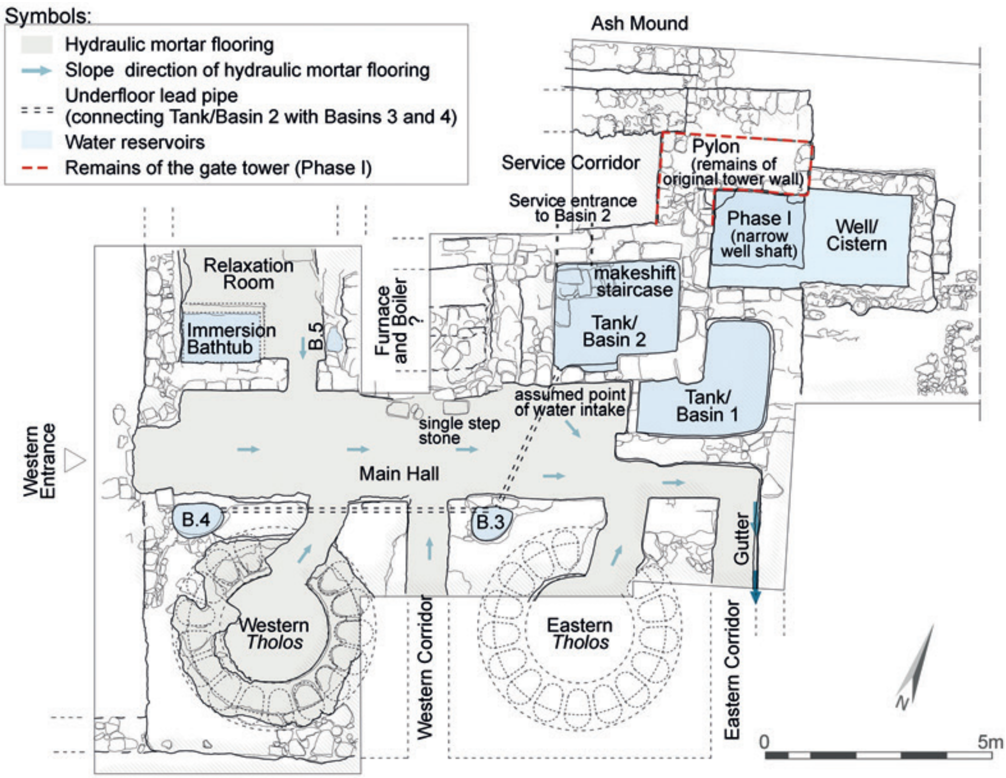


9. The western part of the bath with remains of Western *Tholos*; view to the south (Phot. S.E. Sidebotham).

The perimeter walls of the square-shaped housing of the circular rooms were largely robbed, but probably consisted of regular-shaped anhydrite/gypsum blocks, with a core of brownish clay mixed with hard volcanic pebbles and covered with hydraulic mortar. They were set in foundation trenches dug down to a level *c.* 0.50m below the floor. The foundations, parts of which survive in the south-eastern corner and eastern part of the western *tholos*, comprised flat anhydrite/gypsum stones. The only extant fragment of the perimeter wall preserved above the floor level and situated on the western side of the western *tholos* consisted of some roughly shaped ashlars.

Based on the examples of better-preserved complexes, especially that at Taposiris Magna assumptions can be made concerning the domed roofing of these rooms as well as the presence of niches for bathing accessories in the wall above the bathtubs.[43] Water accumulated in the recesses in the front part of the bathtub bottoms after bathing would have been likely poured directly onto the floor in the centre of the room.

[43] Fournet, Redon 2009.



10. Plan of the bathhouse with Well/Cistern (Drawing: S. Popławski, M. Woźniak).

CORRIDORS

Two corridors, 0.90m-wide, ran east of each *tholoi*. They were oriented N–S and opened onto a central hall (see below) (**Fig. 10**). Only 2.2m of their northern ends has been explored so far, but they must have been as long as the side of the *tholos* housings they abutted. The flooring was a hydraulic one in both corridors, and the eastern one was equipped with an open gutter also of hydraulic mortar, sloping down to the south. These passages probably provided communication between the suggested southern entrance of the baths, the cloakrooms (see below) and the main part of the bathhouse (Main Hall, *tholoi* and relaxation room; see also below).

MAIN HALL

The large rectangular hall reached by the two corridors was 2.40m wide and oriented E–W. It measured 10m in length to the western edge of Basin 1, and 13m to the eastern wall of the building (**Fig. 10**). Its central role, connecting the bathing area with the relaxation room and main facilities of the building, is common to many Hellenistic-style baths.[44] The hall of the Berenike bathhouse ended with a wide door opening to the west, and was organised in that direction, which suggests the important role of this western entrance. The western doorway, with a stone paved area in front of it, on the western side, led to an area further west of the bathhouse, with a brownish ground surface, most likely a courtyard. The eastern end of the hall led to the main water reservoirs (Basins 1 and 2). Bathers and attendants could also draw water from the two smaller basins (3 and 4) accessible from the hall on its southern side. No traces of later repairs or additional furnishings were evident on the perfectly preserved, extremely hard, hydraulic hall flooring.

Relaxation room

A relaxation room with traces of an immersion bathtub on its floor, lies in the north-western corner of the building (**Figs 9**–**10**). The excavated part, 2.60m on the N–S axis and 3.20m on the E–W one, constitutes most likely half of its space. The rectangular immersion bathtub sat directly on the hydraulic flooring in the south-western corner of the room. The outer dimensions of the bathtub imprint were 1.80 x 1.20m, the inner ones 1.40 x 0.90m. The room might have been indirectly heated through the eastern wall behind which the furnace and hot water tank were probably located (see below). Moreover, water in the small reservoirs alongside this wall inside the relaxation room was, most likely, warmer than room temperature due to the putative heating system in the neighbouring room. Of these reservoirs only the southern one, rectangular Basin 5 preserved, measuring 0.62m on N–S axis, 0.36m on E–W one and depth of *c*. 0.20m. The doorway from the hall, 0.62m wide, preserved no traces of jambs or a threshold, which might indicate that the relaxation space lacked a closing.

Water system: Basins 1–2 and the well

The water supply system was located in the north-eastern corner of the building (**Figs 3, 10**). It consisted of two reservoirs (Basins 1 and 2) and the well/cistern that supplied them with fresh water. The L-shaped Basin 1 measured 3m on the longer sides, 1.5m on shorter ones (in the north-eastern corner) and was at least 1m in depth. The rectangular Basin 2 was 2.5 x 3m and at least 1m in depth. The total volume of these two main reservoirs was initially estimated at 10,000–17,000 litres.[45] However, after completion of excavations a more precise and safer estimate was 14,000–14,500 litres.

Basin 2, as mentioned above, was connected by a pipe with two small, semi-circular basins (3 and 4) in the housings of *tholoi*. The south wall of Basin 2 in its western part was half as thick as the other walls, which might indicate the presence of an opening above it used for drawing and filling it with water. The bottom of the basin lay about 0.20m below the adjoining floor level and was designed to allow water to run down towards a pipe

---

[44] Bergmann, Heinzelmann 2009: 92; Fournet, Redon 2017a: 105–106, 128–135.

[45] Woźniak 2017: 57; 2019a: 248.

outlet. A few ashlars were later added as steps in the north-western corner of the reservoir, close to the threshold of a probable service entrance from the technical, northern part of building. These makeshift steps were built to facilitate access to the interior of Basin 2 and also to deliver or draw water from there.

Basin 1 abutting the southern wall of the well and south-eastern corner of Basin 2 was, most likely, a later addition. This L-shaped tank also had a thinner western wall. The reservoir floor, sloping west in the direction of the above-mentioned wall, as in Basin 2, lay about 0.20m below the hall pavement.

Heating system

Identification of heating facilities without locating a bath furnace is difficult. Yet, the location of a furnace can be hypothesised in the centre of the northern part of the building, where there is a small rectangular room measuring 2.9 x 2.5m (**Fig. 10**). A wide E–W wall made of roughly dressed ashlars, exposed to a depth of about 1.0m, might have once supported a boiler. A stone step against the northern wall of the Main Hall, so to the south of the room under consideration, suggests that the boiler was stoked from here. The poor state of preservation in this area does not allow any further conclusions, but the location, between the main water reservoirs and the relaxation room with at least one immersion bathtub, favours placing the heating system here. No ash has been documented in the layers excavated so far and the lower layers may yet contain some furnace remains. The entrance to the furnace, probably subterranean, might have been from the north, from the service corridor hypothetically connecting Basin 2, via its northern, service entrance, with the relaxation room. A similar location of the furnace can be observed, e.g. in a Hellenistic public bath at Kiman Fares (Krokodilopolis).[46] The same bath plan, with a furnace between the relaxation room and water system area, was recognised at Buto[47] and Karnak;[48] such a plan was also widely used in Hellenistic baths elsewhere in Egypt.[49]

The northern wall of the service corridor touched upon the southern side of the mentioned ash mound. It was so high and massive that in some moment of functioning of the bathhouse a retaining wall was built,[50] running parallel to the north wall of the service corridor, on its northern side, to control the mound's size and pressure. The function of the service corridor, first recorded in the 2014 season, was made clear in 2022. Also, the provenance of the ash seems obvious now due to the identification of the building as a bath. Given its quantity, the ash was probably discarded here from nearby, most likely from the furnace area whose location, in principle, should have allowed for easy ash disposal and fuel delivery via this corridor.

---

[46] Fournet, Redon 2013: 253, Fig. 13.

[47] Fadl Abd el-Rafa *et al*. 2017.

[48] Boraik *et al.* 2013.

[49] Fournet, Redon 2017a: 106.

[50] Sidebotham 1998: 104–105; Woźniak 2017: 47–50.

WATER CIRCUIT

Supply

The well in the north-eastern corner of the building supplied water to the bath. Nearby Basins 1 and 2, as mentioned above, would have been filled from that source, probably via the service corridor. Bathwater could have been drawn from the side of the Main Hall through putative openings above the intentionally thinner walls of both reservoirs. Lead pipes from Basin 2 could simultaneously fill Basins 3 and 4 located near the *tholoi* entrances, from which bathers and attendants could conveniently draw water (**Fig. 10**). The water level in the tanks would probably not have exceeded the height of the front (northern) walls of Basins 3 and 4. Those walls, therefore, were probably no more than 0.50–0.60m above the hall floor, as higher front walls would have made it difficult to draw from these pools when the water level was low. The water for baths would have been drawn from a depth of at least 3m, taking into account the difference between the hall flooring in the eastern area, which was at 4.0m asl, and the water table in the well at 0.90m asl.

Problems with the water supply, possibly due to a dropping water table, and a presumed growing number of bathers, may have prompted the construction of a second large water reservoir (Basin 1), south-east of the earlier one (Basin 2). This new installation was not connected with the rest of the system. When full, this reservoir could have provided enough water not to have to draw more directly from the well on any given working day. Assuming this interpretation is correct, the daily cycle of supplying the baths might be reconstructed as follows. Basins 1 and 2 would have been filled overnight, letting the water reach an ambient temperature. During opening hours, the bath attendants would have drawn water from Basin 1 to heat it for the needs of the relaxation room. Bathers would have had access to water collected in Basins 3 and 4 near the *tholoi* entrances. Whenever water levels dropped in the interconnected Basins 2 to 4, the main reservoir (Basin 2) would be resupplied from Basin 1 through putative openings above the thinner walls (**Figs 3, 10**). Although Basins 1 and 2 were used mainly for filling the boiler and the other basins, bathers might have also drawn water from them: fragments of amphoriskos, ceramic bowls and large shell valves for drawing water at the bottom of Basin 2 and unguentaria excavated at the bottom of Basin 1 suggested, as early as 2014–2015, its bathing-related function. The water-heating system and the manner of filling the immersion bathtubs remain unclear. Possibly this was done via the service corridor, a theory to be tested in future excavation.

The total maximum capacity of all four basins was approximately 15.74m^3 (15,740 litres).[51] Assuming that no extra water was taken from the well during any given day of operation, the *per diem* consumption would not have exceeded 15.75m^3, excluding water in the boiler, if it had been filled during the night.

[51] The capacity of the largest one, Basin 2, was *c.* 7.50m^3 (7,500 litres); of the Basin 1, *c.* 6.75m^3 (6,750 litres); Basin 4, *c.* 0.77m^3 (770 litres); Basin 3, *c.* 0.72m^3 (720 litres).

The Roman bath of Antoninus Pius in Carthage operated in this manner, using only water supplied to the cisterns at night.[52] However, the capacity of the Carthage bath was much greater than the Hellenistic one at Berenike, approximately 4,000m^3 per day and water was transported to it via an aqueduct. Moreover, it would have been greatly uneconomical in the circumstances of Berenike (or other baths throughout Graeco-Roman Egypt) to use the large amount of water needed to feed Roman-style communal immersion pools[53] and it might be the reason why such pools were never built in this region.[54]

DRAINAGE

None of the uncovered bathtubs at Berenike had drains and no drains have been recorded anywhere in the facility. The used water was drained, by bathers themselves or attendants, from the bathtubs directly onto the adjacent floors, as suggested by their sloping at about a 2° angle away from the tubs. The incline is approximately 0.2m over a 9m-long flooring. Counter slopes made of hydraulic mortar protected all the walls, except the eastern one, from damage by running water. The angles of the floors indicate drainage to the hall and farther east, to the corridor on the eastern side of the eastern *tholos*. Alongside the eastern edge of the eastern corridor excavations recorded an open gutter, made of hydraulic mortar leading away to the south (**Fig. 9**). As the end point has yet to be excavated, the ultimate destination of the drained water remains unknown.

SUMMARY

The hydraulic remains thus far excavated at Berenike represent a Graeco-Egyptian type bath.[55] It has a well-organised three-part layout: a presumed entrance with a cloakroom (still to be excavated) on the south, the bathing area with two *tholoi* in the centre, and the heated part, with relaxation room and technical facilities, occupying the northern side. Analogous systems have been excavated in Egypt at Buto, Euhemeria, Karnak, Kom el-Khamsin, Theadelphia and Xois.[56] Unlike those, the Berenike bath had corridors introduced east of the *tholoi*, leading from the southern part of the bathhouse to the Main Hall. This facilitated access to the hall and via the hall to the *tholoi*, enabled them to be entered not only from the western direction, but also from the south. Entrances from different directions could indicate separate facilities for males and females. However, this could also be interpreted (pending the completion of the excavations) as separate access to the bathhouse from the south, directly from the workshops of the 'fort area' and indirectly from the west, via the enigmatic courtyard covered with brownish ground. The latter area may be remains

[52] Wilson 2001: 91–92.
[53] Trümper 2009: 145.
[54] Boussac, Fournet, Redon 2009; Redon (Ed.) 2017.
[55] Fournet, Redon 2017a: 105–108.
[56] Fournet, Redon 2017a: 105–108.

of a *gymnasion*. Two *tholoi* with just one entrance, each opening onto a hall, like that in Berenike, exist at Theadelphia,[57] Buto[58] and Xois.[59]

The Berenike bath was equipped with a well-designed, easy-to-use and efficient architectural and water management system. Hip-bathtubs, used for bathing in a sitting position, would have required relatively little water, and it can be assumed that water drained from the bath was recycled for industrial or agricultural purposes.

The brief period of use of the Hellenistic bath at Berenike, in contrast to the centuries-long operation of facilities of this kind elsewhere in Egypt,[60] suggests that either it was no longer necessary or, more likely, the circumstances changed to the point that its further operation was impossible. Evidence from the excavation of the nearby well[61] revealed that the water supply must have failed at some point, probably in the last decades of the third century BC.[62] An effort (in phase IIa and b of the well) to widen the chamber and add more rainwater-collecting structures seem to corroborate this hypothesis. These actions reflect a lowering of the water table. By about 200 BC the well was finally abandoned and eventually filled with windblown sand. The bath ceased to operate and the ruined building started to serve as a quarry for ready building materials and the site of a cemetery for the residents of the city.

CONCLUSIONS

Current knowledge about the water resources of Roman Berenike indicates that any public bath construction would have been an expensive luxury because of the need to bring in water from wadis lying at a distance to the west of the city. To date, excavations have recorded no Roman-era bath in Berenike. In the early-Hellenistic settlement, however, the situation was, apparently, completely different. Appropriately designed infrastructures, wise exploitation of local conditions and resources and a more humid climate[63] eliminated the need for expensive and labour-intensive transportation of water from sources outside the city. The Hellenistic-era well at Berenike always provided ample water.

The construction of a bath in the Ptolemaic settlement, which signalled Berenike's access to truly Hellenistic urban culture, reflected improved living conditions during the middle and later half of the third century BC. The excavation of the bathhouse yielded insights into everyday life in a town that was at the time one of the most important Red

[57] Fournet, Redon 2017a.

[58] Fadl Abd el-Rafa *et al.* 2017.

[59] Fournet, Redon 2017a; 2017b: 434–435.

[60] Fournet, Redon 2017a; Trümper 2009: 162.

[61] These include, for example, several levels of accretion rings on the sides of the main chamber and additional niches, as well as traces of fireplaces in the sandy fill of the chamber, well below the oldest and highest level of the water table defined by the most prominent accretion ring and the top of the water erosion traces on the walls of the main chamber.

[62] Woźniak, Harrell 2021: 354–364.

[63] Woźniak *et al.* 2021: 267–276; Woźniak, Harrell 2021.

Sea ports, serving dozens of elephant-hunting stations and outposts located on today's coasts of Sudan, Eritrea, Djibouti and Somaliland.[64]

Identification of the bathhouse also explained the origins of an enigmatic mound of ash from the burning of mangrove,[65] which was locally available, as attested also by archaeomalacological studies of the Hellenistic-period.[66] Mangrove wood is of sufficient calorific value to make it excellent fuel for heating the baths and the bathwater. It must have been easily accessible and found in abundance. Moreover, it was used in large quantities and probably over short periods of time, to the point that poorly dried, almost 'green' wood was used.[67] Overall, the presence of substantial mangrove thickets in the Berenike lagoon indicates a much larger freshwater inflow through Wadi Mandit, Wadi Umm Salim al-Mandit, and Wadi Kalalat in Hellenistic times.[68] The ash mound also contained sherds of amphorae, which most probably served as containers for bathing oil and wine consumed in the relaxation area of the baths, but which could also have been used to carry water. The goat, sheep and fish bones found as rubbish discarded with the ash[69] could reflect a practice of preparing various dishes, either baked directly on coals or in ceramic vessels, for the bathers and/or attendants, as is still the case today in traditional baths across North Africa and the Middle East.

The bath was probably also one of the main meeting places for Berenike's inhabitants and a key point in the town's infrastructure, this due to its central location, between the industrial-warehouse zone to the west, in the area of the fort, the shipyards and workshops in the south-western embayment and the residential part of Berenike to the east.

Acknowledgements

The authors would like to thank the directors of the Berenike Project: Steven E. Sidebotham (University of Delaware), Mariusz Gwiazda and Iwona Zych (Polish Centre of Mediterranean Archaeology, University of Warsaw) and all other members and institutions cooperating in the work and study of the magnificent site at Berenike. Without their help, expertise and comprehensive support the excavation of the bath would not have been possible. We would also like to thank members of the 'Ababda tribe, our best employees and friends. Szymon Popławski's participation was possible due to a grant awarded to Rodney Ast and Olaf Kaper by the Thyssen Foundation for the Isis Temple Project.

[64] Casson 1993; Burstein 2008; Sidebotham 2011: 39–53; Cobb 2018: 52–56; Woźniak 2022.

[65] Vermeeren 1998: 345–347.

[66] Mangrove thickets no longer grow in the Berenike lagoon (Woźniak *et al.* 2021: 267).

[67] Vermeeren 1998: 346.

[68] Today, mangroves grow on the shores of the Red Sea only near the mouths of the great wadis reaching far into the mountains (e.g. Wadi el-Gemal); see: Mahmoud 2010: 44; Khalil 2015: 587.

[69] Van Neer, Ervynck 1998: 364, 362.

References

Aldsworth, F.G., Sidebotham, S.E., Wendrich, W.Z. 1995: The Town Site: Survey, Plan, and Description, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1994. Preliminary Report of the 1994 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 13–20

Angelakis, A.N., Chiotis, E., Eslamian, S., Weingartner, H. 2016: Underground Aqueducts Handbook, Boca Raton, https://doi.org/10.1201/9781315368566 (accessed August 2022)

Bard, K.A., Fattovich, R. (Eds) 2007: Harbor of the Pharaohs to the Land of Punt: Archaeological Investigations at Mersa/Wadi Gawasis, Egypt, 2001–2005, Napoli

Bard, K.A., Fattovich, R. 2010: Spatial Use of the Twelfth Dynasty Harbor at Mersa/Wadi Gawasis for the Seafaring Expeditions to Punt, *JAEI* 2/3, 1–13

Bard, K.A., Fattovich, R., Ward C.A. 2007: Sea Port to Punt: New Evidence from Marsa Gawasis, Red Sea (Egypt), [*in*:] Starkey, J., Starkey, P., Wilkinson, T. (Eds), Natural Resources and Cultural Connections of the Red Sea, *Society for Arabian Studies Monographs* 5, Oxford, 143–148

Bergmann, M., Heinzelmann, M. 2009: The Bath at Schedia, [*in*:] Boussac, M.-F., Fournet, T., Redon, B. (Eds), Le bain collectif en Égypte, *EtudUrb* 7, Le Caire, 87–100

Boraik, M., el-Masekh, S., Guimier-Sorbets, A.-M., Redon, B. 2013: Ptolemaic Baths in Front of Karnak Temples. Recent Discoveries (Season 2009–2010), *CahKarn* 14, 47–77

Boussac, M.-F., Fournet, T., Redon, B. (Eds) 2009: Le bain collectif en Égypte, *EtudUrb* 7, Le Caire

Brun, J.-P., Faucher, T., Redon, B. 2017: An Early Ptolemaic Bath in the Fortress of Bi'r Samut (Eastern Desert), [*in*:] Redon, B. (Ed.), Collective Baths in Egypt 2: New Discoveries and Perspectives, *EtudUrb* 10, Le Caire, 13–24

Burstein, S.M. 1989: Agatharchides of Cnidus, On the Erythraean Sea, London

Burstein, S.M. 2008: Elephants for Ptolemy II: Ptolemaic Policy in Nubia in the Third Century BC, [*in*:] McKechnie, P., Guillaume, Ph. (Eds), Ptolemy II Philadelphus and his World, *Mnemosyne-Suppl.* 300, Leiden-Boston, 135–147

Casson, L. 1993: Ptolemy II and the Hunting of African Elephants, *TAPA* 123, 247–260

Cobb, M.A. 2018: Rome and the Indian Ocean Trade from Augustus to the Early Third Century CE, *Mnemosyne-Suppl.* 418, Leiden-Boston

Fadl Abd el-Rafa, M., Abd el-Nabi, W.I., Lecuyot, G., Redon, B. 2017: A New Ptolemaic Bath Building at Buto/Tell el-Fara'in – A Preliminary Report, [*in*:] Redon, B. (Ed.), Collective Baths in Egypt 2: New Discoveries and Perspectives, *EtudUrb* 10, Le Caire, 25–40

Fournet, T., Redon, B. 2009: Les bains souterrains de Taposiris Magna et le bain de tradition hellénique en Égypte, [*in*:] Boussac, M.-F., Fournet, T., Redon, B. (Eds), Le bain collectif en Égypte, *EtudUrb* 7, Le Caire, 113–138

Fournet, T., Redon, B. 2013: Heating Systems of Greek Baths. New Evidence from Egypt, [*in*:] Lucore, S.K., Trümper, M. (Eds), Greek Baths and Bathing Culture. New Discoveries and Approaches, Leuven-Paris-Walpole, 239–263

Fournet, T., Redon, B. 2017a: Bathing in the Shadow of the Pyramids: Greek Baths in Egypt, Back to an Original Bath Model, [*in*:] Redon, B. (Ed.), Collective Baths in Egypt 2: New Discoveries and Perspectives, *EtudUrb* 10, Le Caire, 99–138

Fournet, T., Redon, B. 2017b: I. Catalogue of the Greek *Tholos* Baths of Egypt, [*in*:] Redon, B. (Ed.), Collective Baths in Egypt 2: New Discoveries and Perspectives, *EtudUrb* 10, Le Caire, 389–436

Fraser, P.M. 1972: Ptolemaic Alexandria I. Text, Oxford

Grewe, K. 2008: Tunnels and Canals, [*in*:] Oleson, J.P. (Ed.), The Oxford Handbook of Engineering and Technology in the Classical World, Oxford, 319–336

Harrell, J.A. 1996: Geology, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1995. Preliminary Report of the 1995 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 99–126

Harrell, J.A. 2019: Geological Studies from the 2019 Season at Berenike Part A: The Early Hellenistic Well in Trench BE15/18–104 and the Berenike Bedrock, 23 March 2019, unpublished report, s.l.

Herbich, T.M. 2007: Magnetic Survey, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1999/2000. Report on the Excavations at Berenike, Including Excavations in Wadi Kalalat and Siket, and the Survey of the Mons Smaragdus Region, Los Angeles, 22–29

Khalil, A.S.M. 2015: Mangroves of the Red Sea, [*in*:] Rasul, N.M.A., Stewart, I.C.F. (Eds), The Red Sea. The Formation, Morphology, Oceanography and Environment of a Young Ocean Basin, Heidelberg-New York, 585–597

Klitzsch, E., List, F.K., Pohlmann, G., Handley, R., Hermina, M., Meissner, B. 1987: Geological map of Egypt (1:500 000): sheet NF 36 NE Berenice, Cairo

Mahmoud, T. 2010: Desert Plants of Egypt's Wadi El Gemal National Park, Cairo

Peremans, W., van't Dack, E. 1952: Prosopographia Ptolemaica II: L'armée de terre et la police, n[os] 1825–4983, *StudHell* 8, Louvain

Redon, B. (Ed.) 2017: Collective Baths in Egypt 2: New Discoveries and Perspectives, *EtudUrb* 10, Le Caire

Redon, B. 2022: Ghozza/Berkou, Desert Networks project, http://desertnetworks.huma-num.fr/sites/DN_SIT0115 (accessed August 11, 2022)

Said, R. 1990: Red Sea coastal plain, [*in*:] Said, R. (Ed.), The Geology of Egypt, Rotterdam, 345–359

Sidebotham, S.E. 1995a: Survey of the Hinterland, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1994. Preliminary Report of the 1994 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 85–101

Sidebotham, S.E. 1995b: The Excavations, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1994. Preliminary Report of the 1994 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 21–27

Sidebotham, S.E. 1996: The Excavations, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1995. Preliminary Report of the 1995 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 7–97

Sidebotham, S.E. 1998: The Excavations, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1996. Report of the 1996 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 11–120

Sidebotham, S.E. 1999: The Excavations, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1997. Report of the 1997 Excavations at Berenike and the Survey of the Egyptian Eastern Desert, Including Excavations in Shenshef, Leiden, 3–94

Sidebotham, S.E. 2000: Survey of the Hinterland, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1998. Report of the 1998 Excavations at Berenike and the Survey of the Egyptian Eastern Desert, Including Excavations in Wadi Kalalat, Leiden, 355–377

Sidebotham, S.E. 2007: Excavations, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1999/2000. Report on the Excavations at Berenike, Including Excavations in Wadi Kalalat and Siket, and the Survey of the Mons Smaragdus Region, Los Angeles, 30–165

Sidebotham, S.E. 2011: Berenike and the Ancient Maritime Spice Route, Berkeley-London

Sidebotham, S.E., Barnard, H. 2000: Excavations in Wadi Kalalat, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1998. Report of the 1998 Excavations at Berenike and the Survey of the Egyptian Eastern Desert, Including Excavations in Wadi Kalalat, Leiden, 379–402

Sidebotham, S.E., Gates-Foster, J.E. (Eds) 2019: The Archaeological Survey of the Desert Roads between Berenike and the Nile Valley: Expeditions by the University of Michigan and the University of Delaware to the Eastern Desert of Egypt, 1987–2015, *ASOR ArchRep* 26, Boston

Sidebotham, S.E., Wendrich, W.Z. 1998: Berenike: Archaeological fieldwork at a Ptolemaic-Roman port on the Red Sea coast of Egypt (1994–1998), *Sahara* 10, 85–96

Tallet, P. 2016: The Egyptians on the Red Sea Shore during the Pharaonic Era, [*in*:] Boussac, M.-F., Salles, J.-F., Yon, J.-B. (Eds), Ports of the Ancient Indian Ocean, Delhi, 3–19

Taterka, F. 2020: Przez morze do Ziemi Boga: Egipskie wyprawy do krainy Punt i ich znaczenie w religii i ideologii władzy kraju faraonów, Warszawa

Tomber, R.S. 1998: The Pottery, [*in:*] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1996. Report of the 1996 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 163–180

Trümper, M. 2009: Complex Public Bath Buildings of the Hellenistic Period. A Case Study in Regional Differences, [*in*:] Boussac, M.-F., Fournet, T., Redon, B. (Eds), Le bain collectif en Égypte, *EtudUrb* 7, Le Caire,139–179

Van Neer, W., Ervynck, A. 1998: The Faunal Remains, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1996. Report of the 1996 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 349–388

Vermeeren, C.E. 1998: Wood and Charcoal, [*in*:] Sidebotham, S.E., Wendrich, W.Z. (Eds), Berenike 1996. Report of the 1996 Excavations at Berenike (Egyptian Red Sea Coast) and the Survey of the Eastern Desert, Leiden, 331–348

Wilcken, U. 1963: Grundzüge und Chrestomathie der Papyruskunde 1: Historischer Teil, Hildesheim

Wilson, A. 2001: Urban Water Storage, Distribution, and Usage in Roman North Africa, [*in*:] Koloski-Ostrow, A.O. (Ed.), Water Use and Hydraulics in the Roman City, Dubuque, 83–96

Wilson, A.I. 2008: Hydraulic Engineering and Water Supply, [*in*:] Oleson, J.P. (Ed.), The Oxford Handbook of Engineering and Technology in the Classical World, Oxford, 285–318

Woźniak, M. 2017: Shaping a city and its defenses: fortifications of Hellenistic Berenike Trogodytika, *PAM* 26/2, 43–60

Woźniak, M. 2019: Berenike of the Ptolemies. A Hellenistic desert city/fortress, [*in*:] Peterková Hlouchová, M., Bělohoubková, D., Honzl, J., Nováková, V. (Eds), Current Research in Egyptology 2018. Proceedings of the Nineteenth Annual Symposium, Czech Institute of Egyptology, Faculty of Arts, Charles University, Prague, 25–28 June 2018, Oxford, 239–252

Woźniak, M.A. 2022: Berenike – why there? Environmental, economic and logistic conditions of the Hellenistic port/base location, [*in*:] Durand, C., Marchand, J., Redon, B., Schneider, P. (Eds), Networked Spaces: The Spatiality of Networks in the Red Sea and Western Indian Ocean, *Archéologie(s)* 8, Lyon, 73–96

Woźniak, M.A., Harrell, J.A. 2021: When the well runs dry: climatic instability and the abandonment of early Hellenistic Berenike, *Antiquity* 95/380, 349–366

Woźniak, M., Rądkowska, J.K. 2014: In Search of Berenike of the Ptolemies. The Hellenistic Fort of Berenike Trogodytika, Its Localization, Form and Development (Part One), *PAM* 23/1, 505–526

Woźniak, M.A., Sidebotham, S.E., Osypińska, M., Carannante, A., Rądkowska, J.K. 2021: Ptolemaic Berenike: Resources, logistics and daily life in a Hellenistic fortress on the Red Sea coast of Egypt, *AJA* 125/2, 247–281

Zych, I., Sidebotham, S.E., Hense, M., Rądkowska, J.K., Woźniak, M. 2016: Archaeological Fieldwork in Berenike in 2014 and 2015: From Hellenistic Rock-cut Installations to Abandoned Temple Ruins, *PAM* 25, 315–348

ÉTUDES et TRAVAUX

XXXV / 2022

IKŚiO PAN

Institut des Cultures Méditerranéennes et Orientales
de l'Académie Polonaise des Sciences

INSTITUT DES CULTURES MÉDITERRANÉENNES ET ORIENTALES
DE L’ACADÉMIE POLONAISE DES SCIENCES

ÉTUDES et TRAVAUX

XXXV

IKŚiO PAN

VARSOVIE
2022

Publication scientifique cofinancée par le programme
du ministère polonais des Sciences et de l'Enseignement Supérieur
intitulé « Développement des revues scientifiques » pour les années 2022–2024
(projet n° RCN/SP/0612/2021/1)

ISSN 2084-6762
(jusqu'en 2011 : 0079-3566)
e-ISSN 2449-9579

Version première en papier, imprimée en Pologne – 100 copies
Version électronique accessible sur
http://www.etudesettravaux.iksiopan.pl

Édition : Polskie Towarzystwo Historyczne et Wydawnictwo Neriton, Warszawa

Conception générale de la couverture : J. Iwaszczuk
Photographie de couverture : Phot. P. Košárek ;
© Djedkare Project (Substructure de la pyramide de la reine Setibhor, Saqqara Sud)

Table des matières