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Terracotta Pipelines at *Maloutena* Remarks on the Water System in the Residential District of Ancient Nea Paphos, Cyprus

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Abstract: This paper presents the results of studies on the ancient terracotta pipelines discovered during excavations conducted since 1965 by the Polish Archaeological Mission of the University of Warsaw in the so-called *Maloutena* area, the residential district of the Hellenistic-Roman capital of Cyprus, Nea Paphos. The pipelines were examined in terms of the pipe types they were composed of, their construction and maintenance aspects, chronology, function and structural interrelations to recognise the role they played in the water management system of *Maloutena* and Nea Paphos over time.

Keywords: terracotta pipelines, Nea Paphos, Hellenistic-Roman Cyprus, water tower

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Terracotta pipelines[1] are a commonly encountered feature at Eastern Mediterranean Graeco-Roman urban sites. Although often preserved fragmentarily, upon closer examination they may constitute a valuable source of knowledge on the ancient urban water systems. Addressing this assumption, the author undertook studies on the terracotta pipelines discovered during excavations conducted since 1965 by the Polish Archaeological Mission of the University of Warsaw[2] in the residential district (the so-called *Maloutena* area) of the Hellenistic-Roman capital of Cyprus, Nea Paphos (**Fig. 1**).

The city was located on the south-western coast of Cyprus, at the small promontory constituting the maritime terrace of massively karstified carbonate rock basement.[3] There are two small periodic rivers in its vicinity, Koskinas in the north and Limnaria in the

[1] To clarify, in this paper the term 'pipe' is used for single clay tube, while the term 'pipeline' is used for a line composed of the numerous joined pipes. Also, hereafter the shortcut 'PP' with the appropriate number will be used to describe particular pipelines.

[2] The Mission, inaugurated in 1965 by Kazimierz Michałowski, was further led consecutively by Wiktor A. Daszewski (1971–2007), Henryk Meyza (2008–2019), and, currently, Ewdoksia Papuci-Władyka.

[3] Kalicki, Chwałek, Frączek 2020: 489.

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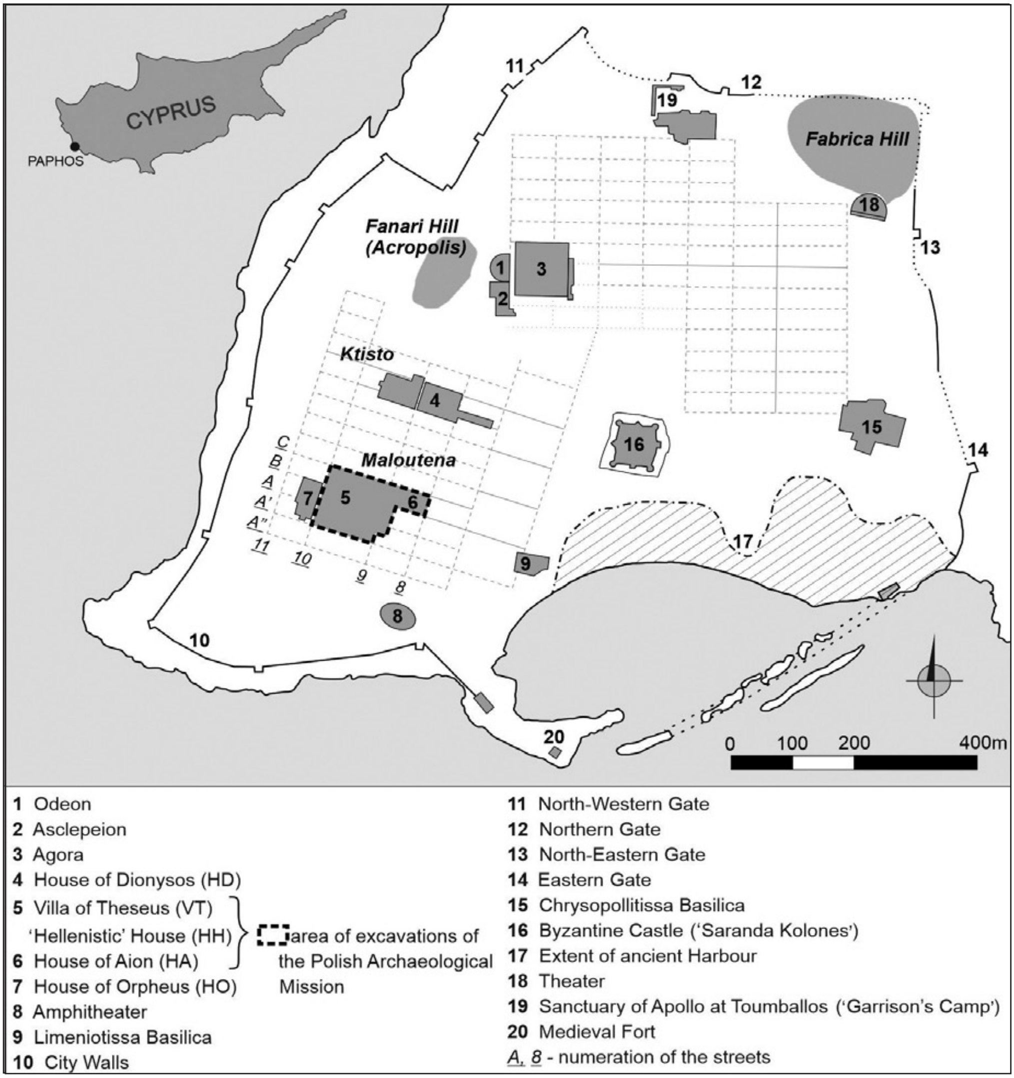

1. Plan of ancient Nea Paphos (Drawing: M.M. Romaniuk; based on: Papuci-Władyka 2020: Pl. 5).

east (and one larger river, Ezousa, further to the east).[4] The local climate is semi-arid,[5] characteristic of Eastern Mediterranean lands, with hot, dry summers and rainy winters

[4] Jolanta Młynarczyk (Młynarczyk 1990: 91) notes about three streams to be located east of the city in antiquity. The largest and farthest to the east one can be identified most likely with the modern Limnaria stream. The second one, about 250m to the west, was just outside the hypothetical course of the eastern city wall. The last one had its mouth west of the eastern pier of the ancient port (therefore within the harbour bay). One of them was possibly mentioned in the tenth-century-AD literary source by Joannes Cameniata (Młynarczyk 1990: 31).

[5] Average rainfall in the south-west coastal area is 480mm per year, while maximum average temperature up to 31° in July and August, and 16–18° in January and February (Sparrow, John 2016: 9).

causing, respectively, seasonal water shortage alternating with storm floods. Due to such hydrological conditions, the city needed an effective water supply and drainage system, of which the manifestation – apart from the other hydraulic installations – are the investigated pipelines.[6]

Founded in the late fourth century BC, over a century later Nea Paphos became the capital of Cyprus under the Ptolemies of Egypt,[7] keeping this function after acquiring of the island by the Romans in 58 BC. The city was destroyed numerous times by earthquakes[8] and rebuilt again until a devastating series of earthquakes in the fourth century AD, after which it never gained its earlier splendour. Until then it was one of the most important cities in the region, which was reflected in the erection of the assumed palace of the Roman governor,[9] Villa of Theseus (hereafter as VT),[10] in the south-western part of the city, in the *Maloutena* area.

Excavations by the Polish mission at the *Maloutena* site revealed relics of numerous wealthy houses (**Fig. 2**).[11] In the Hellenistic and early Roman periods, the buildings – among them the so-called 'Hellenistic' House (hereafter HH) built around the second/first century BC[12] and rebuilt repeatedly until destruction in the first half of the second century AD[13] – were fit into *insulae* drawn by a regular grid of streets.[14] In the late second century AD, this layout was disturbed by the erecting of the VT, which cut Street A (E-W axis) and Street 9 (N-S axis). By its final development phase, dated to the fourth century AD, this building

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[6] Hitherto, no more detailed studies devoted to the past hydrological conditions in the ancient Nea Paphos have been published. It can be said, however, that in the Hellenistic-Roman period the Levant went out through two major peaks of wetter (than today) climate, in which Cyprus was most likely included. The first peak is dated to around 150/100 BC to AD 200/250 (McCormick *et al.* 2012: 180, 183) and the second to various points between the fourth and fifth centuries AD (McCormick *et al.* 2012: 188, 197). Additionally, modern rainfall in Cyprus is decreasing successively, according to the statistics from the last decades of the last century (Hadjioannou 1997 *cit. per* Kambanellas 2012: 303), while intensive development of hydrotechnical infrastructure (drilling of boreholes, construction of retention reservoirs) during last over hundred years (especially since 1960) has resulted into a serious depletion of water in some areas (Kampanellas *et al.* 2003: 9–11, 14). From the above findings it can be concluded that the Nea Paphos area was better watered in the past than today, however, rather not as much as to force a change of the general, semi-arid character of the land. See also footnote 16 below.

[7] Mitford 1980: 1309.

[8] For discussion on the ancient earthquakes that hit Nea Paphos, see: Młynarczyk 1990: 33–34.

[9] Daszewski 1977; Medeksza 1992. For references on the other interpretations of the building, see: Miszk 2020: 154, n. 69.

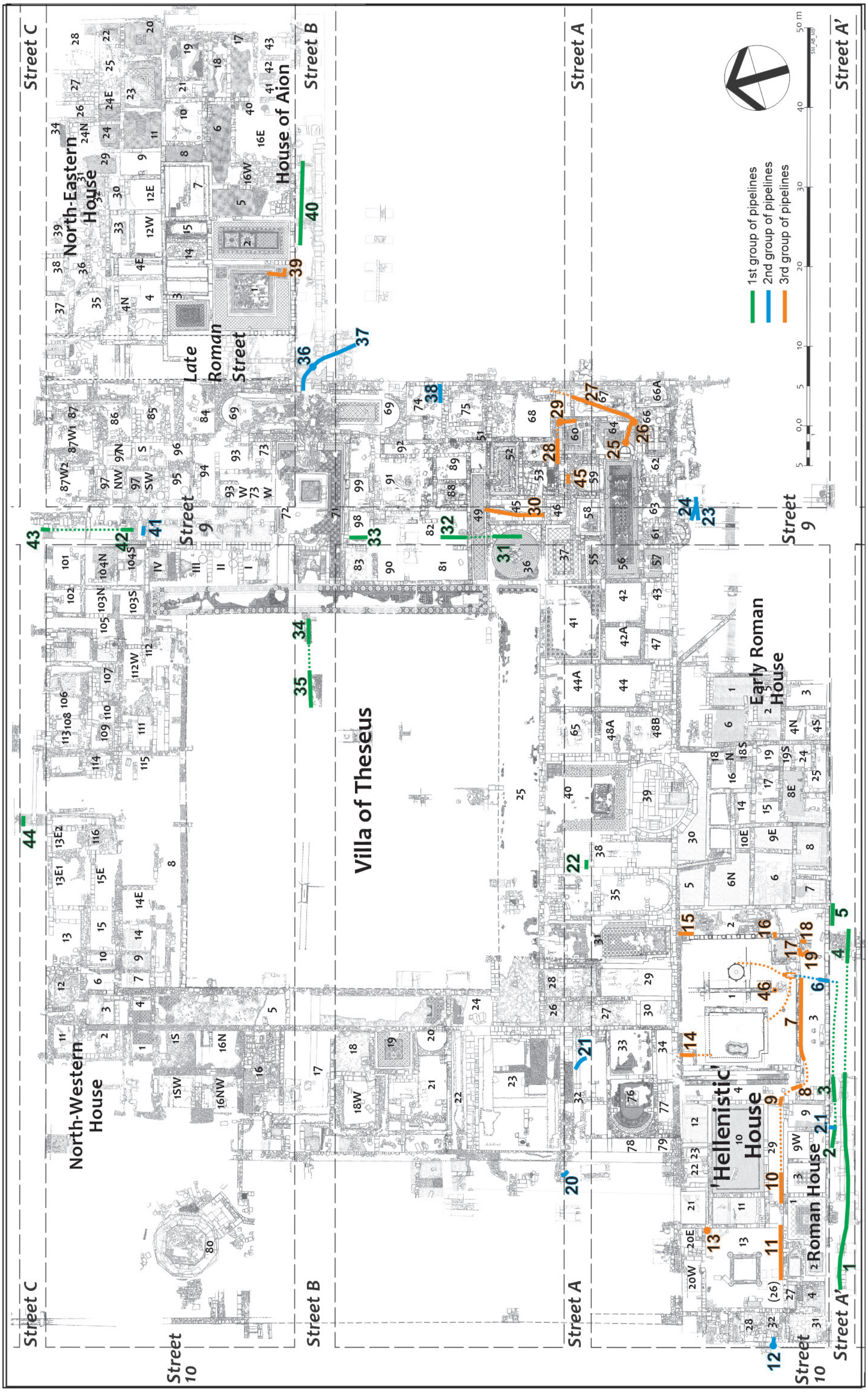
[10] Further, the number added to the abbreviation of the building name marks the number of the particular room or corridor, e.g. HH1 for the Room 1 (Main Courtyard) in HH.

[11] For general overview of structures discovered at *Maloutena*, see: Młynarczyk 2016: 34–35.

[12] Date based on the ceramic material (Daszewski 1994: 103), as well as the stylistic of the mosaic decoration (Daszewski 1991: 83) and of the corinthian capitel (Papageorghiou 1990: 977) found in HH10. These architectural features were incorporated into the later construction of the HH erected most likely after the earthquake of 17/15 BC (Młynarczyk 2016: 34).

[13] In the late second century AD the south-western part of HH was overbuilt by the so-called Roman House (further as RH; Daszewski 1995: 72).

[14] Excavations show that HH occupied only the west part of the *insula* marked by Streets 10, 9, A and A', while east part was occupied by the so-called Early Roman House (Daszewski 2016). For more information on the street layout of Nea Paphos, see: Młynarczyk 1985; 1990: 166–177.



2. Plan of the area under the concession of the Polish Archaeological Mission with investigated pipelines marked: solid line – unearthed pipelines; dashed line – possible course of the pipelines (Drawing: S. Medeksza, M. Słowińska, A. Brzozowska; processing: M.M. Romaniuk).

was extended to the north over an area of several *insulae*, as far as Street C (E-W axis), respecting, however, the general orientation of the layout.[15] At that time new N-S axis route, called the Late Roman Street, was constructed along the east wall of the VT and another wealthy villa, the House of Aion (hereafter HA), was also erected east of it. Soon after the fourth-century earthquakes the area started to degrade, and by the sixth century had been occupied by squatters.

Within the excavated area numerous water-related devices were found, such as underground cisterns/wells,[16] channels, under-street sewers, baths, ornamental pool, impluvium or nympheum.[17] Among them were the terracotta pipelines, particularly important as they connected other elements of the water system, but which have to date not been examined systematically. This article attempts to fill this gap by analysing them in terms of the pipe types they were composed of, construction and maintenance aspects, chronology, possible function and structural interrelations, aiming to understand their role in the water system of *Maloutena* and Nea Paphos over time, and draw more general conclusions about the water supply and distribution within the city.

METHODOLOGY AND LIMITATIONS OF RESEARCH

The fragmentary preservation and limited field-accessibility of the pipelines at *Maloutena* preclude tracking their course from start to destination, and determining, thus, their exact role in the local water system. Since ancient written sources devoted to water architecture,

[15] For architectural description of VT, and the periodisation and characteristic of its building phases, see: Medeksza 1992; 1998.

[16] It can rarely be determined whether a discovered inlet belongs to an underground cistern or a well, especially as some cisterns had well-like narrow, stone-built shafts reaching even several meters down to the ground. To date, only one feature, located at the eastern wall of VT68, may be treated as a potential well due to the groundwater that appeared there at the level of *c*. 1m asl (7.25m below the head level) during excavations. Its freshwater content still needs to be verified as *Maloutena* lies at the maritime terrace, and water table was observed close to the sea level, thus the water might have been contaminated by seawater. The geohydrological survey conducted in the Paphos region did not include the area of the *Maloutena* (Hadjistavrinou, Afrodisis 1977), preventing this issue to be resolved. It concludes, however, that the water from the region shows ‘a high calcium carbonate content, low to medium sodium chlorite content and in some places a high sulphate content due to contamination from gypsum water’ and ‘pH factor ranges from 7.0–8.5, indicating neutral to alkaline water’ (Hadjistavrinou, Afrodisis 1977: 21). The map of the Paphos area (*Ktima 1955*), preceding the major developments of hydrotechnical infrastructure of Cyprus after 1960 and environmental changes caused by them, shows no freshwater intakes in the area west of Saranda Kolones (**Fig. 1**, no. 16), which may support the above hypothesis about the salination of the water. Apart from this, alleged wells were located in the nearby House of Orpheus (further as HO), but were barely mentioned in reports (Christou 1992: 823). Thus far, the closest to *Maloutena* (Hadjistavrinou, Afrodisis 1977), preventing ancient freshwater well (inv. no. S. 173), late Hellenistic in date, was found to the north, at the agora of Paphos, with a similar groundwater level reached at 0.95m asl (Miszk 2020: 142). Together with the fact that the sea level might have changed since ancient times, the above findings make it difficult so far to recognise the original, ancient groundwater level, water quality, and the wells’ potential location in the limits of *Maloutena* without dedicated microregional studies.

[17] A detailed study of these installations is the subject of the author’s PhD thesis and will be published separately.

and literature on the subject provide little comparative material[18] to understand these installations the author was forced to rely above all on the knowledge of the general hydraulic principles, well-established methodological practices[19] and his own careful field observations and analysis of the archaeological context of the finds. The most important assumptions applied in the research are listed below:

1) all the ancient water conduits operated by gravity,[20] thus their inclination determined their flow direction unless they were pressurised as a part of a siphon allowing them to deliver water uphill;
2) the presence of the intentionally cut apertures in the pipes precludes the pressurisation of the pipeline,[21] suggesting its solely gravity flow, with possible exceptions in case of apertures blocked with stoppers applied from the inner side of the pipe (see the case of PP7 below);
3) the muff (male end) in spigot-socket-form pipes is always oriented into the direction of the flow;[22]
4) the character of the filling of the pipeline may suggest its function (e.g. grey, clayish fill in case of waste; emptiness in case of rainwater or sinter in case of spring water);
5) the presence of the sinter deposit (calcium carbonate) inside the pipeline indicates it carried the 'hard', spring water (i.e. abundant in minerals, in contrast with the 'soft' rainwater);[23]
6) a range of sinter within the pipes indicates the average level of the flow – its presence on the whole inner diameter indicates the pipeline was fully filled with water and thus pressurised.

With the above assumptions in mind, the pipelines were examined in terms of their archaeological and architectural context, course, inclination, muff-orientation, methods of construction, maintenance modifications, filling, spatial and functional interrelations, and types of pipes they were composed of. Among the pipes discovered at the site, eight types

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[18] As Femke Martens (Martens 2001: 62, n. 66) rightly points out, neither of the two most important sources, Vitruvius' *De Architectura* and the Frontinus' *De Aqueductu Urbis Romae*, pays special attention to the morphology of the urban water distribution and disposal system.

[19] Martens (Martens 2001: 62, n. 64) warns against false assumptions, unsupported by the archaeological evidence, such as that the 'smaller pipes are for supply, whereas larger pipes serve the purpose of drainage' (referring to Crouch 1984: 359–360), and 'the generalisation that pipes are for supply, whereas built channels are constructed for drainage'.

[20] Mark E. Landon (Landon 1994: 368 *cit. per* Palinkas, Herbst 2011: 314, n. 58) noted the gradient of 0.114% (a fall of 0.04m over a distance of 35m) is sufficient to allow the water to flow through the pipe without added pressure.

[21] Hodge 2002: 114; Palinkas, Herbst 2011: 314, n. 58.

[22] Forbes 1964: 153; Hodge 2000: 41. Field observations, however, show that in the pipelines combined of different pipe types (usually of reused pipes of different shapes and sizes) this rule is not always followed, and muffs' orientation is not constant within one line, as is exampled by PP27.

[23] Sürmelihindi, Passchier 2013: 274–275, Fig. 2. *Notabene* sinter does not have to always be deposited as the water may have lost its mineral content earlier on its way from the source or if there were no conditions conducive to the deposition.

are discussed here. They were distinguished based on their shape, dimensions, ceramic mass (fabric)[24] and special features like potters' marks (**Figs 3–4, Tables 1–2**).[25]

In many cases, the full on-site examination of the objects in question was impossible. Some of them were known only from vague mentions in archival documentation and archaeological reports, while those still accessible in the field formed usually a chain of pipes so closely interconnected that only their external appearance could have been analysed.[26] In fact, the greatest amount of data was obtained from destroyed parts of pipelines, giving a chance to recognise, at least partly, the cross-sections of the pipes, their joints and the kind of material filling their interior. Where it was possible, the interior of the unexcavated parts of pipelines was inspected with a long-cable endoscope camera to examine their further course and possible branches.

RESULTS

THE PIPES

As mentioned above, from among the pipes discovered at the site, eight types were distinguished. Almost all the pipes (**Figs 3–4, Table 1**) were of the spigot-socket form (male end – female end), in which narrowed male flange fit into a female opening with a stop, apart from type 7, which had just a thickened lip at the end(s). The types preserved in the greatest number – among which were types 1, 2 and 3 – had characteristic hourglass, helically ridged bodies. Type 5 had an hourglass body with a smooth surface. In types 4 and 8, bodies were of a slight hourglass shape, while type 6 belled in the middle, all with a smooth or slightly undulating surface. Type 7 was belled at the end(s) but cylindrical in the middle body, with a smooth surface, occasionally helically ridged in the middle. All of them were made on a pottery wheel as the helical ridging suggests, visible especially on the inner surface. The spigot-socket forms usually have the male end consisting of a slightly rounded shoulder and a cylindrical flange thickened toward the flat lip. The female end consisted of a stop – pinched up in types 1–4 and 6, and built up of the body in type 5 – and a flange[27] thickened toward the flat lip. Type 8 stands out a little by more trapezoidal body widened at the male end, the shoulder smoothly transformed into a flange, and a barely noticeable pinched up stop. Numerous pipes, not presented here, are combinations

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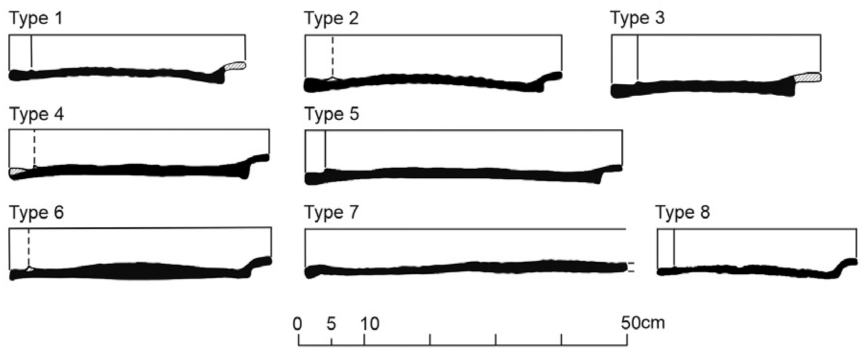
[24] The methodology of the pipe examination was inspired mainly by the studies of Jennifer Palinkas and James A. Herbst (Palinkas, Herbst 2011) on the pipes from Corinth, of Jordan Pickett (Pickett 2016) on those from Ephesus and of Kai Wellbrock on those from Pergamon (Wellbrock 2012).

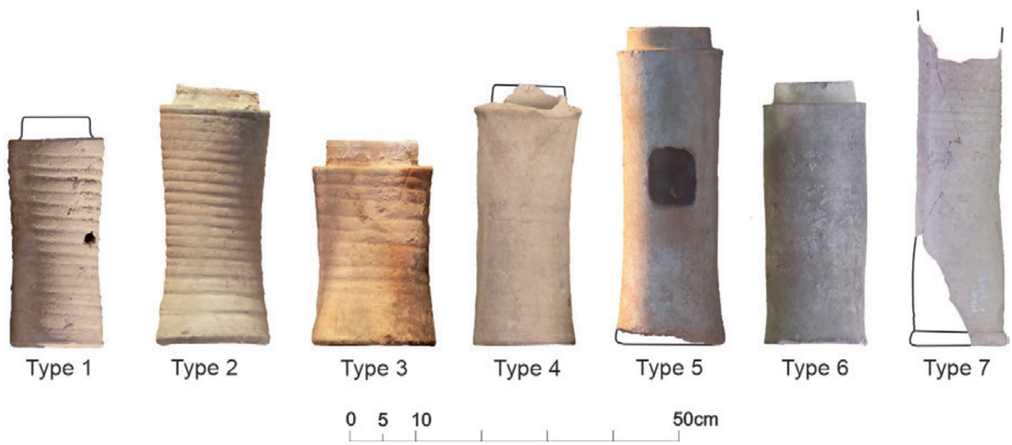
[25] The intention of the author was not to present here the complete catalogue of the pipes from *Maloutena* but the choice of the most common and/or characteristic types, which were accessible to closer examination. The other types of pipes are to be classified and presented in the following stages of the project.

[26] The length of the male flange, thickness of the walls and some other values were available to measure only in single cases thus have been omitted in above general characteristic of pipe dimensions. These values, however, taken from the cross-sections pictured in **Fig. 3**, were placed in the **Table 2** as the indicative, exemplar ones.

[27] The term 'female flange' is used here to describe the part of the female end located between the stop and the lip.



3. Cross-sections of examples of pipes representing particular types; diagonal and dashed lines indicate the reconstructed fragment of the pipe based on the shape of similar pipes (Drawing: M.M. Romaniuk).



4. Orthophotos of the examples of pipes of particular types; dark solid lines indicate reconstructed fragments of the pipe. Type 8 is not presented due to the fragmentary preservation (Phot. and processing: M.M. Romaniuk).

of the above general characteristics, with the one exception of a spigot-socket pipe made unique by its large, cylindrical body encircled with three, regularly distributed bands found at the main entrance of VT (PP37).

The dimensions of the pipes (see **Table 2**) range from 26 to *c*. 49cm[28] for the body length, and from 14.2 to 20.5cm for the outer body diameter. All the types have an elongated body in general, although type 3 is more heavyset. The length of the pipes does not exceed the length of a human forearm, which relates possibly to the wheel-made production[29] and/or to desire to enable application of mortar inside the joints when installing the pipelines.

Most commonly, the fabric of the pipe material (see **Table 3**), as noticed for pipe types 1–2, 4, and 7–8, was hard, harsh in texture, in various shades of yellow, pink, red and brown colours, with prevailing abundant, medium to very large spherical sub-rounded and angular

[28] Maximum value relates to the pipes from PP2 and PP3, not classified in typology, and PP46 (type 7).

[29] Hodge 2002: 113.

inclusions (excluding type 1, in which small to medium size inclusions predominate), manifested often as irregular dark spots visible on the surfaces.[30] A similar fabric seems to be testified for the transport amphora as well as for pipes and other ceramic building materials found at the agora of Nea Paphos and considered to be of local provenience.[31] The fabric of type 6 was hard and harsh, of dark reddish-brown core and pinkish-grey surface, of more granular break, with more varied inclusions. The pipes of type 3 and 5 were made of less harsh fabrics, of reddish yellow and various shades of brown colours, granular in a break, with the domination of fine to medium size inclusions, especially the white ones, which appears abundantly on the smoothed surface of the pipes of the latter type.

Some of the pipes bore marks intentionally made before baking. On both (the only two known) pipes of type 6 (PP39) the handwritten Greek inscriptions AKEC were observed, but of different styles of letters (**Fig. 5a-b**),[32] which may suggest they were not made by the same man, thus possibly showing the name of the workshop owner or some individual that commissioned construction of the conduit. Another inscription – EY – was found on unclassified pipe (**Fig. 5c**). The meaning of these inscriptions remains unclear so far, as no analogy has been found.[33] Moreover, there were also geometrical potter's marks noticed on two pipes of type 4, depicting three circulars in a triangular configuration, possibly made with a stamp (**Fig. 5d**), and also with no analogy known to the author.

Considering the chronology of presented types of pipes, or rather the pipelines (see the section Chronology of the pipelines, below) that they were incorporated in, the material can be divided into two groups: 1) early Roman pipes, types 1–7,[34] dated between the mid-first century and the first half of the second century AD, and 2) late Roman pipes, type 8 and unclassified here pipes from the pipelines of VT and its entrance platform, dated to at least the fourth century AD. Although the dating of the pipes from the first group seems to be reliable, as they were found apparently in their primary context, within the well-made pipelines homogenous in terms of types of pipes used, the dating of the pipes from the latter group is uncertain as they were incorporated in carelessly made pipelines, often of the various types of pipes, possibly reused.[35] These later pipes (apart from type 8) in general give an impression of being more massive and less carefully made.

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[30] The description of the fabrics in **Table 3** conform to the system used by Guy D.R. Sanders (Sanders 1999: 477–478).

[31] Dobosz 2020: 329.

[32] At one of two pipe of type 6 the *epsilon* and lunate *sigma* are rounded, while at the second one they are angular. At least on one pipe the *alpha* has a broken bar (it is unclear on the second one), which gives the beginning of the second century BC as a *terminus post quem* for the manufacturing of these pipes (Mitford 1971: 94, 112).

[33] The only example of inscribed terracotta pipes from Cyprus, known to the author, comes from Amathus, and bears a Greek inscription LB ADRI[anou], suggesting the renovation works of the Hellenistic aqueduct by emperor Hadrian in his second year of his reign (see webpage *Roman aqueducts* and Aupert 2009: 41–42, Fig. 14).

[34] Some doubts occur in case of chronology of the pipes of type 3 (see below).

[35] Pickett (Pickett 2016: 298) notes a similar phenomenon in Ephesus, suggesting that it was 'a manifestation of multiple pipe manufacturers working as contemporaries and contractors on the same project' or 'an indication of stockpilling and reuse of pipes for repairs, perhaps considerably after the date at which the pipes were originally produced'.

5. Inscriptions and potter's mark on the pipes: a-b. inscriptions AKEC on the pipes of type 6; c. inscription EY on the unclassified pipe type (context unknown); d. geometrical potter' mark (triple circle) on the pipe of type 4 (a-b, d. Phot. M.M. Romaniuk; c. Archive of the Polish Archaeological Mission in Nea Paphos)

Terracotta pipes were encountered also in the other spots of Nea Paphos, and some of them seem to resemble the types from *Maloutena*.[36] The spigot-socket (male-female) type pipe with remains of lead counterpart set into it was found by the Australian expedition next to the Antonine *proscenium* wall of the theatre – at the foot of the *Fabrika* hill in the north-eastern part of the city[37] – and seems to correspond to the type 1 due to its helically ridged, hourglass-shaped body. Similarly shaped pipes, corresponding to type 1 or 2, occurred in the conduit found by the French mission (MafaP) close to the Hellenistic mosaic discovered in 1995 south-west of the *Fabrika* hill.[38] Other spigot-socket form pipes are known from the excavations of the Polish mission of the Jagiellonian University conducted at agora of Nea Paphos; some of these pipes seems to have ribbed body as those of types 1–3.[39]

[36] Numerous pipes can be seen also in various spots of the HO, however, this material was not published thus was not included in the comparison.

[37] Green, Stennett 2002: Fig. 13.1; Barker 2007–2008: 43, Fig. 9.

[38] Balandier 2017: 229–230, Fig. 15.

[39] Rosińska-Balik 2020: 191; Miszk 2020: 159, Pl. 24; only a few dimensions of the pipes were given; for those from the pipeline marked as S.119: 35cm in length (of the body?) with slight differences in proportions (around 18cm in diameter, judging by the plan attached), while for those from the S.131: 46cm in length and 17–18cm in diameter.

Noteworthy are also the 'clay water pipes' embedded in the rock-cut channel noticed by Kyriakos Nicolaou in the area of the North-West Gate.[40] They were of the spigot-socket type, brick-red colour and thick walls, which were admittedly not observed *in situ* at *Maloutena*, but where the fragments of similar pipes were found in the Hellenistic contexts, suggesting their relatively early date. Additionally, in nearby Kouklia (Palaepaphos) a pipe analogous in dimensions and shape to type 2 was found – the pipe was named KV.[41] Its chronology, unfortunately, was not specified, nevertheless, such similarities may suggest its provenance from the same, local manufacturer. Beyond the Paphos area, the terracotta pipes can be still observed at numerous other ancient urban sites in Cyprus, e.g. Amathus, Salamis or Kourion, although only those from the last site have been published in more detail.[42]

CONSTRUCTION AND MAINTENANCE OF THE PIPELINES

Pipelines were installed in shallow ditches, just below walking level, to facilitate later access when requiring a repair. Such placement was possible due to the local climate conditions excluding freezing of the ground.[43] The lines were composed of the spigot-socket pipes joined by placing the muff (the male end) of one pipe into the widened end (the female end) of the next. The joints were sealed with mortar skimmed on the inside to a smooth surface, with fingers as the imprints suggest (**Fig. 6**). This material is extremely hard and tightly adhered to the pipe surface, ensuring the durability of the connection. It was white lime with almost no inclusions, possibly corresponding to the mortar recommended by Vitruvius, made of the clarified burnt lime mixed with water and oil,[44] which expands when in contact with water.[45] The conduits were flanked with stones, evidenced in PP2 (**Fig. 8c**), PP3 (**Fig. 8d**), PP4 (**Fig. 8f**), PP7 (**Figs 7b, 10c, 11a)**, PP11 (**Fig. 11d**), PP12 (**Fig. 10d**), PP33 (**Fig. 9b)** and PP43 (**Fig. 9g**) for better stabilisation in the ground. The method of installation of PP46 is unclear, as it is represented only by the one loose pipe of type 7 found in debris of the southern portico of HH1 (**Figs 7e, 12b**).[46]

The lateral tributaries and the elbows, observed in PP2 (**Fig. 8c**), PP11 (**Fig. 11d**) and PP39 (**Figs 7c, 13e**), were realised by fitting the muff of the pipe into the aperture cut in the side of the next pipe. In the elbows, the further pipe was blocked on its female end with stone or ceramic sherd sealed with mortar. As for now, no one-element elbow pipes have been observed. Other direction changes could have been achieved also through the

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[40] Nicolaou 1966: 576.

[41] Last 1975: Table C, Pl. XII.

[42] Last 1975, including some details on terracotta pipes from Kouklia.

[43] Crouch 1984: 359.

[44] Vitr., *De arch*. VIII.6.8. Małgorzata Biernacka-Lubańska (Biernacka-Lubańska 1973: 132, 277) uses a term 'malta' or 'maltha' for this type of mortar.

[45] On the sealing materials, see: Malinowski 1996.

[46] Marking of this pipe(line) in the **Fig. 2** relates to the place where the pipe was found.

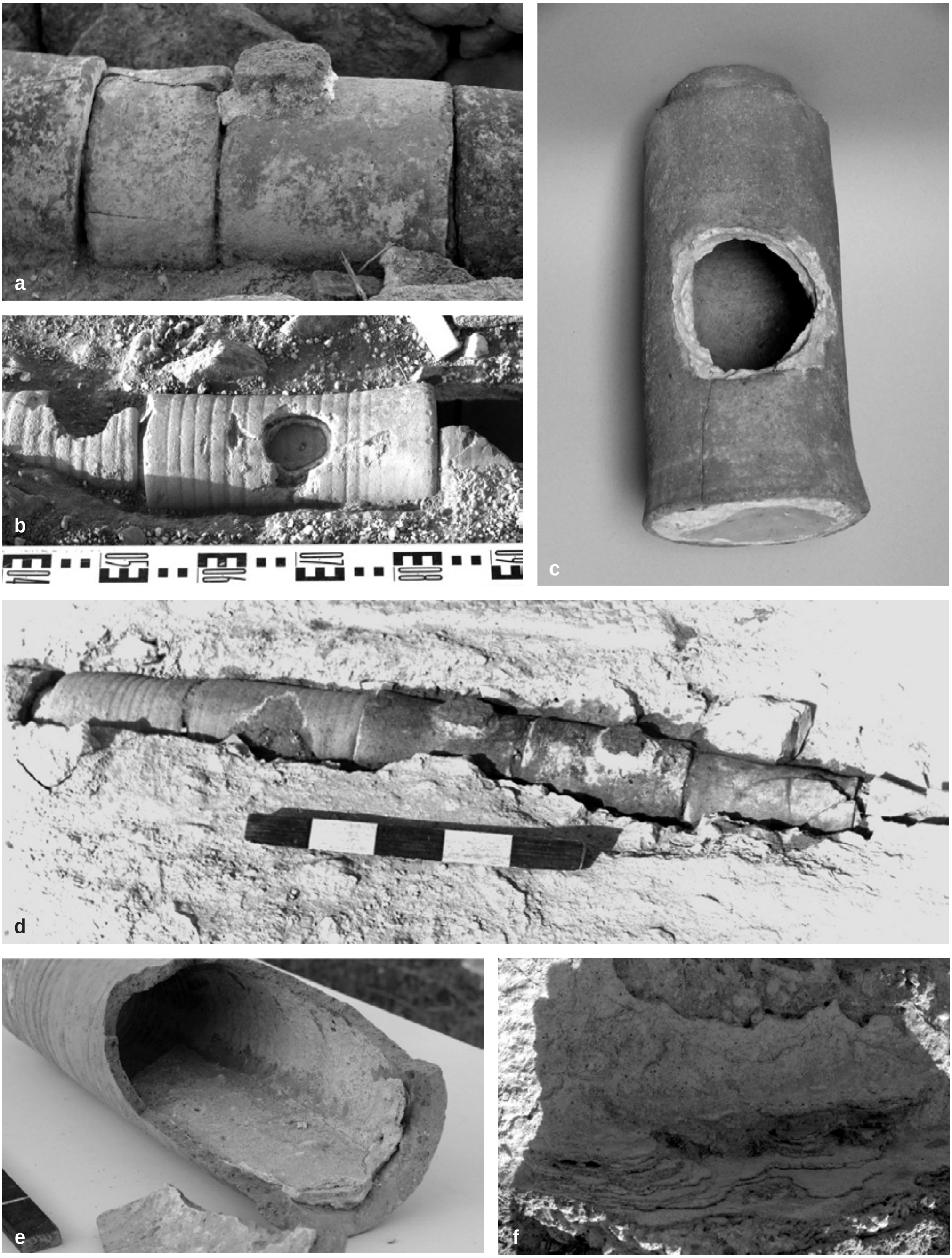
6. Fingerprints impressed in the inner mortar sealing of the joint between pipes; picture taken with an endoscope camera (Phot. M.M. Romaniuk).

settlement/distribution box, as observed in PP6 (**Figs 10c, 12b**), analogical to those from Kourion and its vicinity.[47] Additional solution is to lead the pipeline widely along a curved course, as is illustrated by PP21, PP24 and PP37 (**Fig. 10a-b, e**).

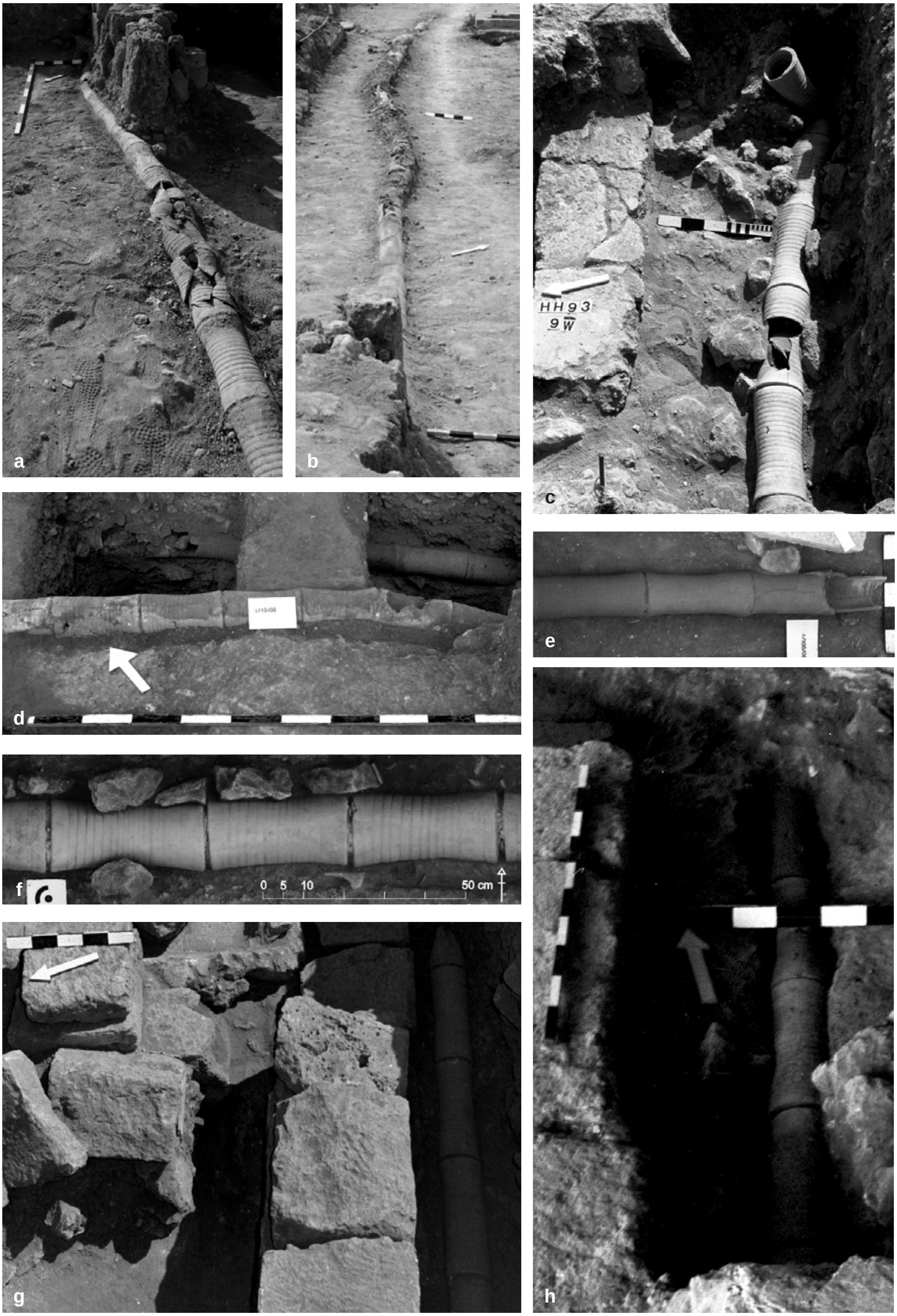
Some of the pipes had the oval or rectangular apertures of hand-size (or smaller) chipped in their tops, a phenomenon well known from many other sites, often considered as inspection holes, to facilitate sealing, cleaning or repairing the pipelines.[48] In PP40 at least eight such holes were observed (**Figs 7a, 9d**). Three of them were apparently made to facilitate better internal sealing of the joint between incompatible elements, as two were made in two adjoined pipes of different diameters, while the third one was in the pipe that was cut into halves and recomposed of these two pieces set in reverse order (**Fig. 7a**). The other five holes in PP 40 may have been made for a similar purpose. All of them were to be closed with stone or ceramic stoppers in mortar, still preserved in some cases (**Figs 7a, 9d**). Another pipe with a hole was observed in PP7 (the only case in the entire line), evidencing possibly unsuccessful and/or unskilful repair (**Fig. 7b**). The pipe was removed once and placed again in its original spot in a half-turned position, with the joints left unsealed, while the hole was closed with a pipe fragment put on the inside, in contrast to other recorded stoppers applied from the outside (an attempt to strengthen perforation of a pressurised line?). Undoubtedly, the conduit was leaking thereafter and went out of use.

[47] For elbow pipes, see: Last 1975: 50, 53, Fig. 7: P17, Table C: P17, Pls VI: 23, XII: P17; for junction/distribution/settlement boxes (tanks), see: Last 1975: 44–46, 54, Fig. 1: 3–4, Tables A, E, Pls I: 3–4, III: 10, 12, IX: 35, X: 37.

[48] For more information and references on this topic, see, e.g.: Jansen 2000: 106, n. 8; Hodge 2000: 41; 2002: 114, n. 46.



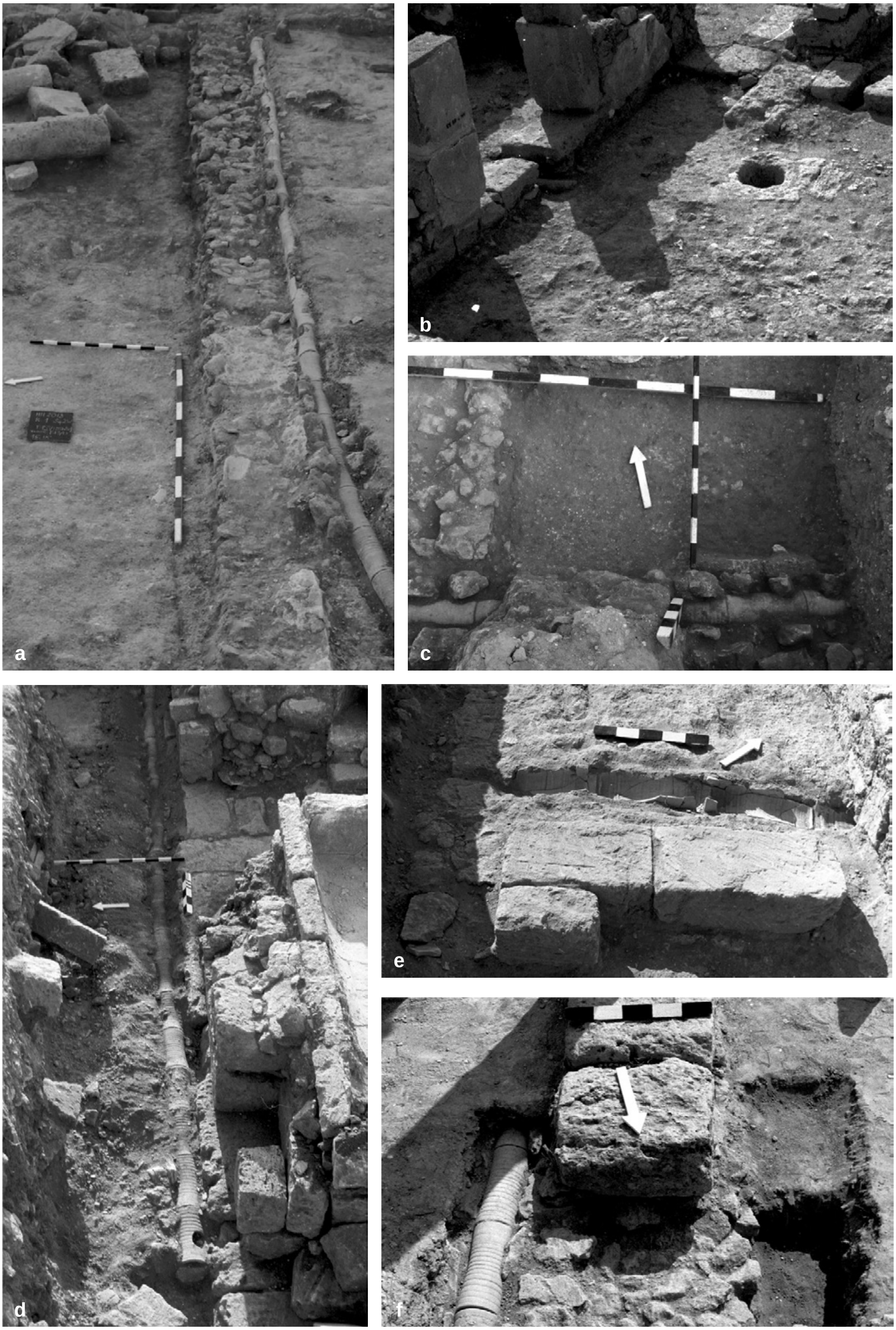
7. Apertures, stoppers and sludge within the pipes: a. PP40, stone stopper closing the aperture in the pipe made of two parts (northern view); b. PP7, terracotta stopper closing the aperture in the pipe (northern view); c. PP39, receiving part of the elbow with an aperture at the side, female end closed with pottery sherd; d. PP27, stone stoppers closing the apertures in the pipes (north-western view); e. PP46, pipe of type 7 with sludge inside; f. sludge in the gutter of the cornice from HH13 (a-b, e-f. Phot. M.M. Romaniuk; c-d. Archive of the Polish Archaeological Mission in Nea Paphos).



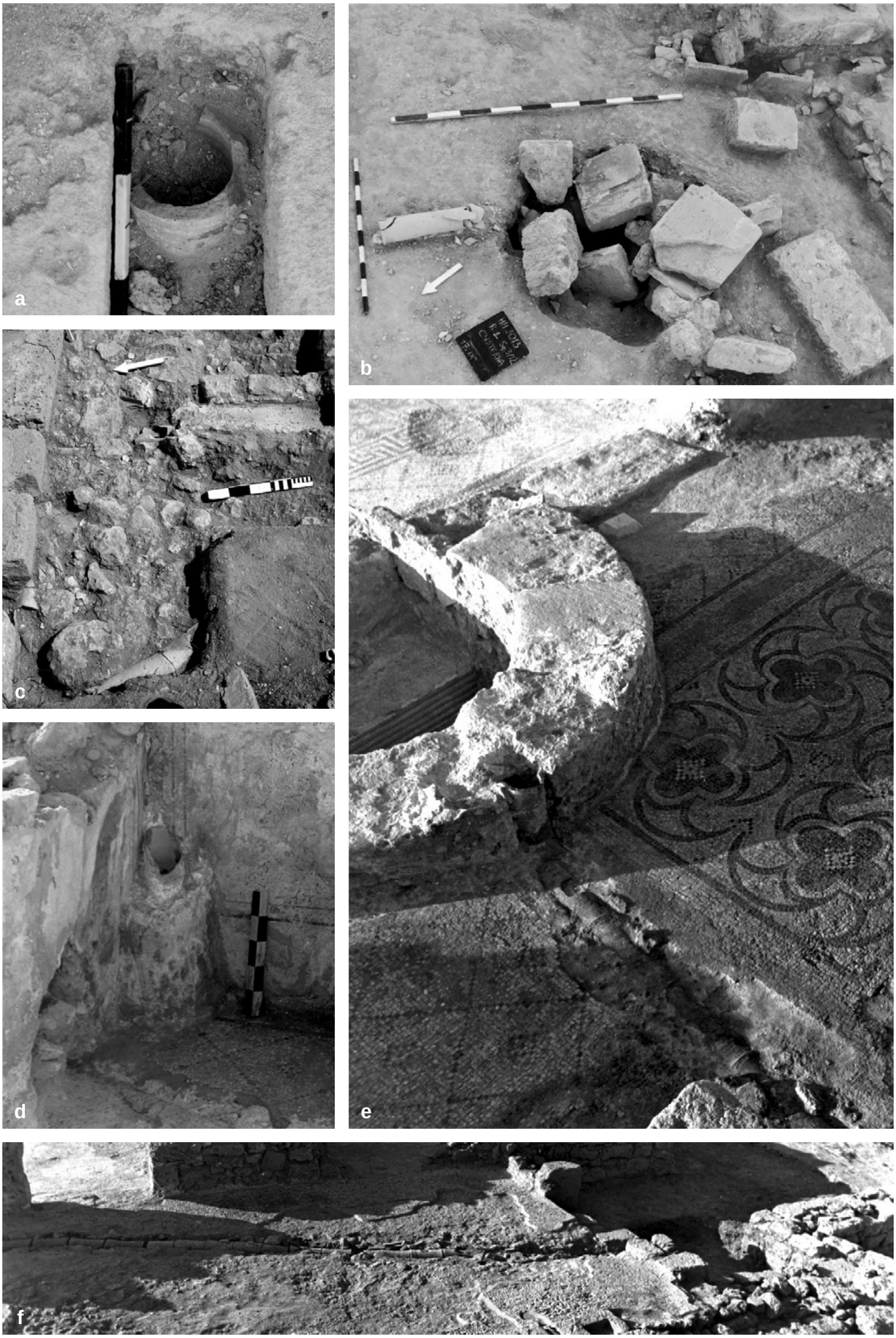
8. Pipelines of the first group: a. PP1 (eastern view); b. PP1 (western view); c. PP2, PP2.1 (eastern view); d. PP1, PP3 (northern view); e. PP22 (northern view); f. PP4 (orthophoto plan); g. PP5 (eastern view); h. PP31 (northern view) (a-e, g-h. Archive of the Polish Archaeological Mission in Nea Paphos; f. Phot. and processing M.M. Romaniuk).

9. Pipelines of the first group: a. PP32 (western view); b. PP33 (eastern view); c. PP34 (northern view); d. PP40 with street sewer and side drain (northern view); e. PP42 (eastern view); f. PP44 (eastern view); g. PP43 (eastern view) (a-d, f-g. Archive of the Polish Archaeological Mission in Nea Paphos; e. Phot. M.M. Romaniuk).

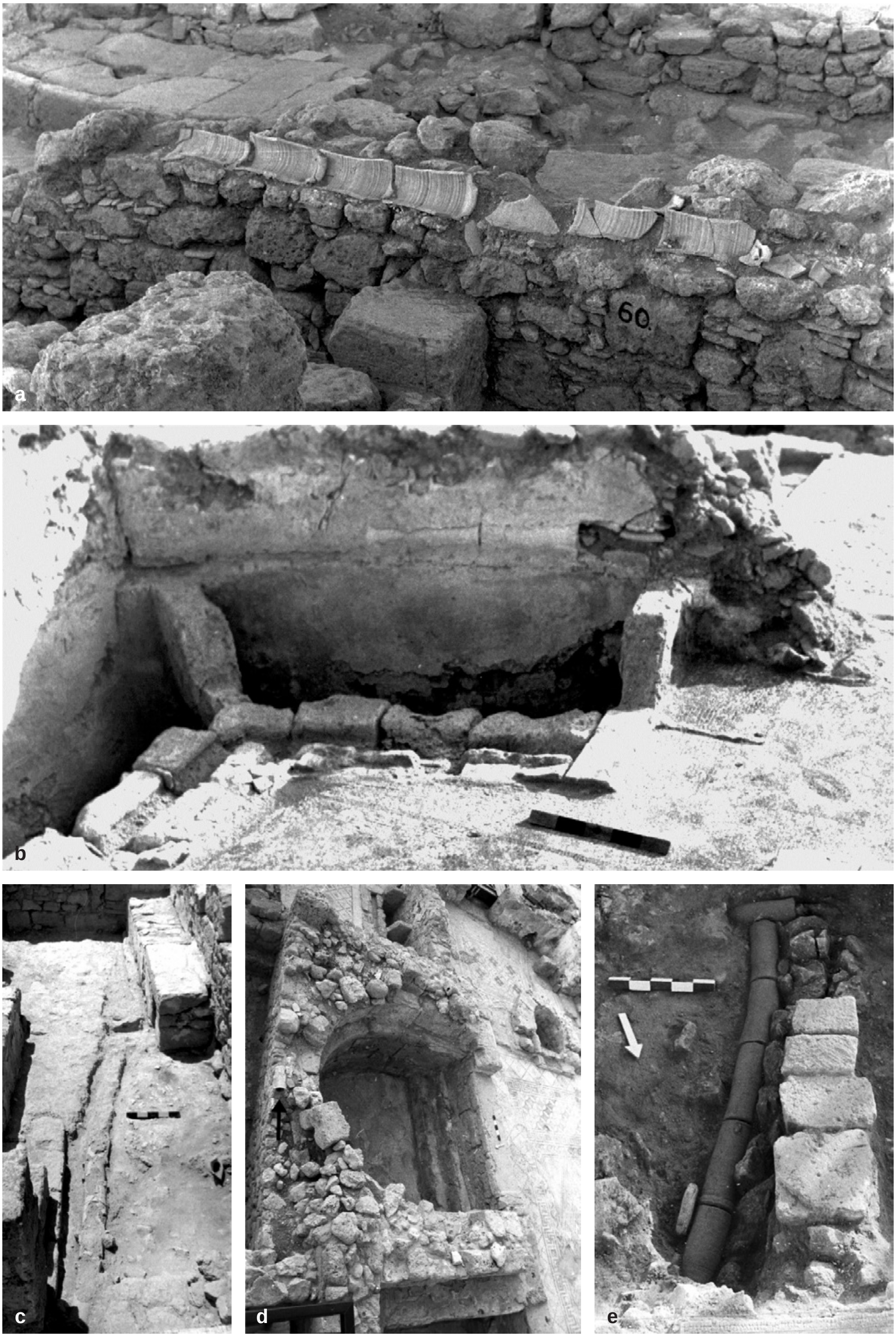
10. Pipelines of the second group: a. PP21 (north-western view); b. PP23 (at the bottom), PP24 (at the top; southern view); c. PP6, PP7, settlement/distribution tank (northern view); d. PP12 (southern view); e. PP37 (southern view); f. PP41 (western view) (a. Młynarczyk 1990: Phot 29; b-f. Archive of the Polish Archaeological Mission in Nea Paphos).



11. Pipelines of the third group: a. PP7 (eastern view); b. PP8, PP9 (south-western view); c. PP10 (northern view); d. PP11 (eastern view); e. PP14 (western view); f. PP15 (southern view) (a-f. Archive of the Polish Archaeological Mission in Nea Paphos).



12. Pipelines of the third group: a. PP16 (western view); b. PP46, pipe of type 7 to the left of the cistern shaft, PP6 and settlement/distribution tank in the top right corner (south-eastern view); c. PP17, PP18, PP19 (eastern view); d. PP25, PP26 (south-eastern view); e. PP25 (north-western view); f. PP27, to the right: corner of the rectangular cistern/well (western view) (a. Phot. M.M. Romaniuk; b-f. Archive of the Polish Archaeological Mission in Nea Paphos).



13. Pipelines of the third group: a. PP28 (north-western view); b. PP29 (eastern view); c. PP30 (southern view); d. PP45 (marked with a black arrow, eastern view); e. PP39 (southern view) (a-e. Archive of the Polish Archaeological Mission in Nea Paphos).

Two joined pipes located in the much-curved point of PP24 also had apertures, possibly to facilitate better internal sealing of hardly accessible curved spot, probably more prone for fault due to not so tight fitting of the pipes contrary to straight-line joints (**Fig. 10b**). A similar situation appeared in PP37, in which, however, the general reason for making the aperture must have been again to facilitate the joining of pipes differing in size (**Fig. 10e**), as in PP27 (**Figs 7d, 12f**).

No sinter deposits were testified inside any of the investigated pipelines. Exclusively the pipe of type 7 had a kind of layered sludge inside, however, of different nature than the sinter (**Fig. 7e**). In general, the conduits were empty inside or filled partly or fully with sediment of apparently post-depositional character.[49]

Spatial distribution and the function of the pipelines

The pipelines recorded at *Maloutena* may be divided into three main groups according to their location and direction (**Fig. 2, Table 4**). The first group represents the primary pipelines running along the streets;[50] the second includes the secondary pipelines running between the streets and the buildings, and the third, the pipelines located in the frame of the buildings.

Sections of the first group were found on the Street A: PP22 (**Fig. 8e**); Street A': PP1 (**Fig. 8a-b**), PP2 (**Fig. 8c**), PP3 (**Fig. 8d**), PP4 (**Fig. 8f**), PP5 (**Fig. 8g**); Street B: PP34 (**Fig. 9c**), PP35, PP40 (**Figs 7a, 9d**); Street C: PP44 (**Fig. 9f**), and Street 9: PP31 (**Fig. 8h**), PP32 (**Fig. 9a**), PP33 (**Fig. 9b**), PP42 (**Fig. 9e**), PP43 (**Fig. 9g**) following the orthogonal layout of the city.[51] Their flow directions and inclinations[52] seem to be overall consistent, from north to south at the meridional Street 9, and from east to west at the latitudinal streets, excluding PP2 and PP3 oriented from west to east. PP1, possibly a continuation of PP4 due to a similar type of pipes (type 2) used, was running slightly meandering through the middle of the street. It was empty inside, without apertures (thus pressurised?), and with no side tributaries over a distance of almost 27m, thus possibly was a freshwater supply, maybe delivering water to the fountains or water towers in the crossroads of the streets. However, the lack of sinter traces, usually left by 'hard' spring water from the limestone

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[49] 'Post-depositional sediment' is understand here as all the sediments deposited inside the pipeline after it went out of use and not related to its original function.

[50] Part of these pipelines were found in the limits of the rooms of the VT. They, however, undoubtedly preceded erection of VT, thus the conclusion they originally were located on the streets.

[51] The systematic pipeline network following the regular, orthogonal layout of the streets, was characteristic for the Hellenistic urban water systems, known from e.g. Priene, Rhodos-town and Lindos (Jansen 2000: 109, n. 18).

[52] According to Młynarczyk (Młynarczyk 1990: 166), Street 9 was sloping from south to north in line with the gradient of the terrain. In general, however, it must have inclined from north to south as it was continuing along the western elevation of the House of Dionysos (further as HD; Młynarczyk 1990: 166) up toward the *Fanari* hill. Regarding the sloping of Street B, from west to east towards the port as Młynarczyk (Młynarczyk 1990: 173) suggests, is questionable in light of the author's measurements of the top level of the slabs covering the under-street canal (most likely indicating the original level of the streets) implying opposite direction of inclination with average level difference of about 11cm at the distance of *c*. 100m.

karstic region of Paphos, raises some doubts, and thus rainwater or light wastewater draining function can not be excluded definitely. PP2 was apparently a drain collecting run-off from the roof at the southern façade of HH as suggested by the presence of the downspout PP2.1. PP40 could have been a drain replacing the main sewer under Street B ceased to function yet in antiquity.[53] It was cut by a stone-built channel leading from HA to the main sewer, that was apparently still used in places as a soak pit (**Fig. 9d**). It seems probable that this construction is a later modification of PP40 (for chronology see below), and possibly this pipeline was originally a supplying line. Other pipelines of the first group are preserved/available insufficiently for closer examination.

Regarding the pipelines of the second group, they were found running from Street A: PP20, PP21 (**Fig. 10a**); Street A': PP2.1 (**Fig. 8c**), PP6 (**Fig. 10c**); Street 9: PP23 (**Fig. 10b**), PP24 (**Fig. 10b**), PP41 (**Fig. 10f**); Street 10: PP12 (**Fig. 10d**); and Street B/Late Roman Street: PP36, PP37 (**Fig. 10e**), PP38. PP41 was probably a drainage due to its inclination and flow direction from the west curb toward the sewer in the middle of Street 9. PP36 of similar function had a form of vertical pipe running from the top of the entrance platform of VT down to the sewer under Street B. PP37, low-quality constructed of reused and not well-fitted pipes with apertures, was sloping down through this entrance to the Late Roman Street, most likely draining water from the vestibule. PP6, although could be ascribed also to the third group due to the fact it was found entirely within the frame of a building, was placed in the second group, as it was connecting Street A' with HH. Apparently, it was transferring rainwater from PP2 and PP3 made of likely the same type of pipes as PP6.[54] PP12, entering the HH from the west, was going bent upwardly, which would suggest it was pressurised supplying for the upper storey. This hypothesis, however, is uncertain, because the pipeline has no visible structural support, thus the question arises as to whether this structure could stand on its own when exposed to pressure forces.[55] The vertical pipe adjoined to its horizontal part without a proper joint (a lack of the sealing traces or nest hole, apart from a small irregular hole) as maybe a secondary makeshift modification to a drain is also confusing. PP23 and PP24, of which the latter cut the former, were running beyond the eastern carb of Street 9 possibly delivering fresh water to the building, as the run-off collecting drain would rather run closer to the wall of the supplied building, judging *per analogiam* to PP2, PP3 and PP6. Other pipelines of the second group are preserved/available insufficiently for closer examination.

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[53] Daszewski *et al.* 2010: 504. It seems that most of the under-street drains had ceased to function by the beginning of the second century AD (see: Młynarczyk 1990: 170–173). It cannot be excluded that some of them had gone out of use earlier, which is suggested by the presence of the possible settlement tank/soak pit built at Street A', close to the southern wall of room RH1. It was draining into the ground – through two outlets made of terracotta pipes – the waste water delivered from the basin north of the RH2 by the stone channel under RH1. The tank was filled up with material comparable with this attested in destruction layers of the HD, dated to the third decade of second century AD.

[54] Pipe type with elongated, ribbed body, similar to type 2, but larger: body length *c*. 45–49cm and diameter *c*. 18–19cm.

[55] Usually such constructions, i.e. the siphons, were strengthened with stone, brick or concrete structures (see the water towers in Discussion below).

The pipelines of the third group appeared in HH: PP7 (**Figs 10c**, **11a**), PP8 (**Fig. 11b**), PP9 (**Fig. 11b**), PP10 (**Fig. 11c**), PP11 (**Fig. 11d**), PP13, PP14 (**Fig. 11e**), PP15 (**Fig. 11f**), PP16 (**Fig. 12a**), PP17 (**Fig. 12c**), PP18 (**Fig. 12c**), PP19 (**Fig. 12c**), PP46 **(Figs 12b**); VT: PP25 (**Fig. 12d, e**), PP26 (**Fig. 12d**), PP27 (**Figs 7d, 12f**), PP28 (**Fig. 13a**), PP29 (**Fig. 13b**), PP30 (**Fig. 13c**), PP45 (**Fig. 13d**); and HA: PP39 (**Fig. 13e**).

In the first building, three pipelines – PP11, PP13 and PP16 – were probably the drainage due to their downspouts. PP11 was running along the southern wall of the Western Courtyard towards the east. Its first pipe from the west had the female end blocked with a stone stopper, and a circular nest for the unpreserved downspout running possibly through the niche in the nearby wall. PP13 was found in the north-eastern corner of the Western Courtyard (HH13). It was preserved only in a few pieces of the lowest pipe of the downspout, through which water was running to the ceramic funnel and next by the stone channel presumably to a rectangular cistern at the west part of the courtyard. PP16, placed in the niche cut in the stylobate of the eastern portico of the Main Courtyard (HH1), had a form of a narrow deeply ribbed pipe installed vertically with an eastward inclination. It may have been intended for draining rainwater from the roof and/or of the surplus water from the rectangular reservoir located in the south-east corner of the courtyard. Another possible drain, PP14, located in the north-western corner of the Main Courtyard, may have been draining water to the north from the large rectangular pool located to its south.[56] PP7 and PP15, running – respectively – to the east along the southern stylobate and the north along the eastern stylobate, made of the same type of pipes (type 1), belonged possibly to the same conduit. This cannot be, however, verified as the continuation of the first line disappeared after its intersection with PP6. Possibly PP10 in HH29 was the beginning of PP7, as it was made of the same type of pipe (type 1) and running at the same level. These two sections may have been connected by PP8 and PP9. If this hypothesis is right, then the absence of tributaries, relatively constant level on over 35m-long distance (measuring from PP7 to PP10), small diameter of the pipes[57] used and lack of the apertures (apart from the one discussed above), may suggest that it was a supplying line, maybe even pressurised. It seems less probable that it was a run-off drain as it is questionable if water could successfully flow on such distance without inclination. Moreover, its length would be incomprehensible, as to drain the water to the nearby streets or cisterns it could be led on the much shorter course. PP6, of which chronological and structural relation with PP7 cannot be determined due to the poor state of preservation of their intersection, was running through the settlement/distribution tank located in the south-east corner of the Main Courtyard (HH1). This tank was distributing water (from PP6, see above) in two directions: to the west – probably to the large rectangular basin – and the north – possibly to the small circular pool.[58] PP46 (pipe type 7) – found nearby – was most likely the gutter of the southern portico of HH1.

[56] Meyza *et al.* 2017: 401, 403–404, Figs 2–4 (inv. nos S.2/14, S.20/16).

[57] As stated earlier, diameter should not be taken by itself as a criterion for interpreting pipe functions, but in combination with other indicators it can be helpful. Small diameter pipes seem to be more prone to obstruction if they would carry waste, thus the conclusion is that they belonged rather to the supply line.

[58] For details about these pools, see: Meyza *et al.* 2017 and Romaniuk 2017.

This is suggested by the place it was found, and the layered sludge resembling gritty mortar inside the pipe (**Fig. 7e**). It was identical to that observed in the gutter of the cornice blocks of the Western Courtyard (**Fig. 7f**), being possibly the deposit taken by water flowing from the mortared flat roof. Other pipelines from HH are preserved/available insufficiently for closer examination.

Another cluster of the third-group pipelines was found in the bath complex of VT.[59] In *apodyterium* (VT64) two pipelines, PP25 and PP26, the first going downward in the back wall of the semicircular basin and continuing through the mosaic floor to the eastern wall, and the latter running downward in the thick-walled mortar sleeve in the south-eastern corner of the room, were possibly drainage. The first was probably to drain surplus water from the semi-circular basin and the latter for rainwater from the roof. They both were likely connecting with horizontal PP27, which runs through the mosaic floor to the northern wall of another *apodyterium* (VT67), being most likely directed toward the large rectangular cistern/well in VT68.[60] Another possible drain was the horizontal PP28 built-in in the north wall of the latrine (VT60), made of pipes of type 8. Possibly in this group also PP29 should be included, incorporated into the eastern wall of this room with inclination toward the south. It was made of the pipes (unclassified here) similar to ones from the vertical drains in the *apodyterium* VT64. Putting aside the question of whether these two pipelines were connected at some point in the north-eastern corner of the latrine, at least the latter could lead to the round hole cut in the first stone support of the seats, to flush the north-east part of the latrine sewer or to supply small water channel in front of the seats. As for now, no second-group pipelines have been testified to feed the baths with the freshwater from the external supply. Thus they might have relied on the water from the mentioned cistern/well in VT68.[61] Other pipelines from the VT are preserved/available insufficiently for closer examination.[62]

The last pipeline of the third group is PP39 from the HA, running under the mosaic of HA1, from north to south and turning east. Possibly it drained wastewater from the mosaic or water surplus from a cistern in the HA15.[63]

CHRONOLOGY OF THE PIPELINES

Analysis of the archaeological context shows that the pipelines of the first and second group, apart from those from the Street B/Late Roman Street, correspond with early Roman street

[59] Daszewski 1976: 194–206.

[60] Daszewski 1976: 204. Muffs' orientation within PP27 is not constant but most of the muffs seem to be oriented toward the VT68.

[61] For brief discussion on the possible function of this feature, see above footnote 16. If it was a well with saline water then the hypothesis about feeding the baths by it is doubtful.

[62] Noteworthy, terracotta pipes in the VT were used not only to transport water but also to channel hot air through the walls of the bath building and outside of it, as is suggested by the negative of ribbed-body pipe incised in the concrete back wall of the semicircular basin in the southern wall of VT62.

[63] Karageorghis 1987: 687, Fig. 39; 1988: 837, Fig. 77.

levels, from the mid-first century to the first half of the second century AD. They may have possibly occurred in several phases, as PP2 and PP3 were found in the context overlying PP1 and PP4, while PP23 was cut by PP24. The discrepancy occurs in the case of PP34, under which were found numerous fragments of a mosaic dated by its stylistic to the turn of the second and third century AD.[64] However, the considerable depth at which the pipeline appeared and the type of pipes used[65] may suggest an earlier date. Another discrepancy occurs in the dating of the PP40, as it is associated in general with the second-century-AD context, but in places this chronology can be moved even to the fourth century AD, possibly associated with later modifications of the line. Considering the pipelines from Street B/Late Roman Street (PP36, PP37), they must have been later, related with the erection of the VT in its final appearance in the fourth century AD.

Apart from PP19, PP20 and PP21, for which the context was dated to the second/first century BC, the periodisation of the pipelines of the third group is similar to the two other groups. The pipelines found in the limits of the HH may be dated between the mid-first century to the first half of the second century AD, with emphasis on the second half of the first century AD as the time of their installation. Those from the VT must have been later, as they were laid during the rebuilding of the residence and establishing of the baths in its south-eastern corner some time in the fourth century AD. In the case of the PP39 from the HA, only *terminus ante quem* can be tentatively suggested to the middle of the fourth century AD due to the dating of the mosaic overlaying the pipeline.[66]

DISCUSSION

THE PIPELINES OF *MALOUTENA* AND THE WATER SUPPLY OF NEA PAPHOS

Attempting to specify the periodisation of the early Roman pipelines from *Maloutena* some suggestions may be given concerning a chronology of the pipelines discovered at the agora of Nea Paphos. The two earliest ones were to be installed during Julio-Claudian's reign (27 BC–AD 68),[67] while the later one was after the earthquake of the Flavian times.[68] It seems that these installations, both from *Maloutena* and the agora,[69] were destroyed at the same time, along with surrounding structures, due to the massive earthquake, which was to ruin also the nearby HD, that occurred in the second century AD, possibly in AD 126.[70] This catastrophe must have struck a vast part of the city and caused serious damage

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64 Information obtained from archival documentation.

65 It was similar to type 2, but more elongated (*c*. 41cm long and *c*. 14–15cm wide) and with a ribbed body.

66 Karageorghis 1985: 954.

67 Miszk 2020: 148–149; inv. nos S.131 and S.182.

68 Rosińska-Balik 2020: 191; inv. no. S.119.

69 Miszk 2020: 152; the given date relates to the time when rooms 1 and 2 – to which the pipeline S.119 was associated – finally went out of use.

70 Hayes 1977: 96. For alternative dating – closer to the half of the second century AD – see article on the weight from agora in this volume (Łajtar 2021).

to urban infrastructure, with the water system at the forefront, as is additionally evidenced by the fact that at the same time a number of Hellenistic sub-street sewers and underground cisterns/wells at *Maloutena*,[71] as well as at the agora,[72] were filled up.

Considering the organisation of the early Roman water network at *Maloutena*, it seems that the inhabitants relied heavily on rainwater supplies, which were collected and distributed over the buildings possibly for feeding decorative pools,[73] gardening,[74] bathing[75] or storage in the cisterns for further use. Some of the pipelines, however, running through the streets (PP1 and PP4) and within HH (PP7, PP8, PP9, PP10, PP15) could have also transported fresh water from the aqueduct, but this assumption is uncertain due to the lack of sinter deposits inside them. There is no doubt, however, that the city was once provided with an aqueduct supply – as suggested by its numerous elements found within and around the city[76] – delivering water probably from the area of Tala, *c*. 8.5km north of the city, through Lemba and Chlorakas.[77] In the Roman urban water system model in general, water from the aqueduct was reaching the distribution tanks located at the elevated points of the city, from which, through *castella divisoria*, was to be distributed to the different consumers in the city, that is especially the street fountains, baths and private houses.[78] In the case of the Nea Paphos, such points were at the *Fanari* hill (*c*. 20m asl) to the north and *Fabrika* hill (*c*. 24m asl) to the north-east from *Maloutena* (**Fig. 2**).[79] The latter hill is considered by Jolanta Młynarczyk to be the best spot for the outlet of a water supply system, a pressure tower to channel the water further into several directions.[80] The rock-cut underground cisterns (floor level at 12m asl) found at *Fanari*, of which the date was not specified, were fed by the side branch of the rock-cut aqueduct running through the hill (floor level at 16m asl). The inlet and side outlet of this channel are still visible at, respectively, the north and the east slope of the hill.[81] Conceivably it was related to the pipeline

[71] Only a few of the underground cisterns/wells (from around forty known) located at the investigated area were explored. Excavations show that most of the cisterns appeared in the Hellenistic period and were forgotten already during the habitation phase of VT (Młynarczyk 1990: 185, 189–190).

[72] Miszk 2020: 145.

[73] Meyza *et al.* 2017; Romaniuk 2017; see below, footnote 90.

[74] Possibly after the rebuilding of HH in the end of the first century AD (Brzozowska 2016: 46, n. 3) at the Main Courtyard (HH1) the garden was established (Daszewski 1994: 104–105; Meyza *et al.* 2017: 400, 405, 413).

[75] See below pages 391–392 and footnotes 59 and 105, as well as Rekowska *et al.* 2021, in this volume.

[76] For information on the remains of the ancient aqueduct found in the vicinity of Paphos, see: Hadjisavvas 1977: 227–228.

[77] For general discussion and references on the aqueduct supply in Nea Paphos, see: Młynarczyk 1990: 222–223; for some update on aqueduct at *Fabrika*, see: Bessac 2016: 108–109, Figs 3–4; Balandier, Guintrand 2016: 137–138, Figs 39–43.

[78] For general discussion and references on the Graeco-Roman urban water system model, see e.g. Jansen 2000; Wilson 2008: 293–309.

[79] Both elevations according to Google Earth (accessed September 16, 2021).

[80] Młynarczyk 1990: 223.

[81] Młynarczyk 1996: 198, Fig. 5. Additionally, at the top of the *Fanari* also the open-air, rectangular, rock-cut cistern can be seen.

running on the modern top (*c*. 8m asl)[82] of the city wall near the North-West Gate, mentioned above.[83] The pipes bear the sinter deposit inside indicating they were a part of the freshwater conduit, maybe of Hellenistic date. In the case of *Fabrika*, south of the theatre, two meters below the ground level, the terracotta pipelines ran as well, although their date is not precised.[84] It seems possible these pipelines were related to clay pipes found during excavations of the Department of Antiquity east of the King Mall Avenue in 2014, which may have been a part of a Hellenistic and Roman-era aqueduct.[85] The cistern on the *Fabrika*, supplied most likely with the stone-slab-covered channel running from the north, allegedly functioned in the second century AD.[86] It seems too late, then, to relate it with the *Maloutena* pipelines of the early Roman phase, although the mentioned date is given as a time of utilisation of the cistern, which does not exclude the possibility that it had appeared earlier. Whether these pipelines could have indeed been supplied by an aqueduct then? As for now, it cannot be ruled out that a Hellenistic aqueduct existed at the time of construction of *Maloutena* pipelines, and was still exploited, renewed by subsequent rulers, as is illustrated by the later activity of emperor Hadrian in Amathus.[87] As Cassius Dio stated emperor Augustus was to provide Nea Paphos with funds for post-earthquake reconstruction,[88] thus a renovation of the earlier waterworks may also have occurred. On the other hand, the mid-first century AD was a time when numerous cities in the Roman Imperium were provided with new aqueducts by emperor Claudius, among them at least three Cypriot cities – Kyrenia, Salamis, and Soloi – as can be ascertained from epigraphic material.[89] It seems quite possible then that Nea Paphos, a priority as the capital and most important city of Cyprus at that time, would also obtain an adequate water supply, if needed. An interesting fact is that in the first century AD ornamental water devices appeared in Nea Paphos, such as the circular pool in the Main Courtyard of the HH[90] and the nympheum nearby the Theater at the foot of *Fabrika* hill.[91] The foundation of such installations are often associated with the introduction of an aqueduct providing an abundant

[82] According to Google Earth (accessed September 16, 2021).

[83] See above, page 373, footnote 40.

[84] Peristianis 1927: 37 *cit. per* Młynarczyk 1990: 222, n. 263. The depth at which the pipes were discovered relates to the ground level from the twenties of the past century (as noted by Peristianis).

[85] See webpage *CyprusMail*; Raptou 2016: 60–61, Fig. 13.

[86] Balandier, Guintrand 2016: 137.

[87] See above, footnote 33.

[88] Cass. Dio., *Historiae* LIV.23.

[89] Skevi Christodoulou (Christodoulou 2015: 231–232) briefly discusses three inscriptions related with these waterworks. For Kyrenia, see: Mitford 1950: 17–18, no. 9; for Salamis, see: Nicolaou 1963: 48–49, no. 12; for Soloi, see: Mitford 1950: 28–31, no. 15.

[90] Romaniuk 2017. The question of how this pool was fed, with constantly flowing freshwater or water stored in cisterns, is still open. Although it seems to have been fed with rainwater by PP2, PP3, PP6, these lines may have carried at the same time water from an aqueduct. The freshwater would be more preferable for fish, which were probably bred in this pool (Romaniuk 2017) rather than stagnant water from cisterns, which would have to be used during dry periods.

[91] Barker 2016: 99.

water supply and thus enabling usage for purposes exceeding basic needs, as in Pompeii.[92] All these presumptions may suggest the introducing of a new (or additional) aqueduct supply to the city still in the first century AD, which would have enabled the spreading of Roman water culture among the local community. According to Frontinus,[93] obtaining a water connection required approval from the Emperor himself, which implies that only wealthy and influential persons were able to obtain such a privilege. Thus, if to assume that indeed the HH was supplied with the water from the aqueduct, possibly by PP6, PP7, PP8, PP9, PP10 and/or PP12, it would be in line with the suggestion made by Młynarczyk that the building might have been the seat of the Roman governors of Cyprus during the first century AD.[94]

While continuing technical considerations on the early Roman aqueduct, the question is whether the water delivered to *Maloutena* could have been flowing through the pipelines by pressure. The lack of the sinter does not allow for an easy answer. What can be ascertained, however, is the slope of the potentially freshwater supplying pipelines, PP1 and PP4, achieving 68cm on a distance of 45m, equal to 1.5cm/1m, which is much more than sufficient for effective gravity flow.[95] As to whether the pipelines may have been pressurised, a clue may be provided by the triple-perforated cuboid stone blocks, fitted together in a spigot-socket pattern, discovered in the Western Courtyard of the HH (**Fig. 14a-b**). They have been interpreted to date only as reused parts of the siphon, possibly belonging to a *castellum aquae*, leading the water through three parallel conduits diverged in three different directions with its last, base segment.[96] A block similar to this base block and dated to the Julio-Claudian dynasty's reign was found at the agora of Nea Paphos. It had a triple perforation oriented upwards and specially profiled furrow for a horizontal pipe branch visible on the top of the succeeding stone blocks on one of its sides.[97] It seems more likely to the author that the pillars made of such blocks (**Fig. 14c**) may have been originally crowned with small tanks – up to which one conduit was bringing water, while two others drained it downward – and indeed functioned as small water towers (i.e. pressure towers). They were working possibly the same way as those in Pompeii[98] or Palmyra[99] (**Fig. 14d**)

[92] Jashemski 1992: 111. The introduction of the aqueduct made possible the more generous use of water resulting in the appearing of the decorative pools and fountains in the Pompeian gardens, which became their characteristic features.

[93] *Aq.* 99.3, 103.2 and 105.1.

[94] Młynarczyk 2016: 34.

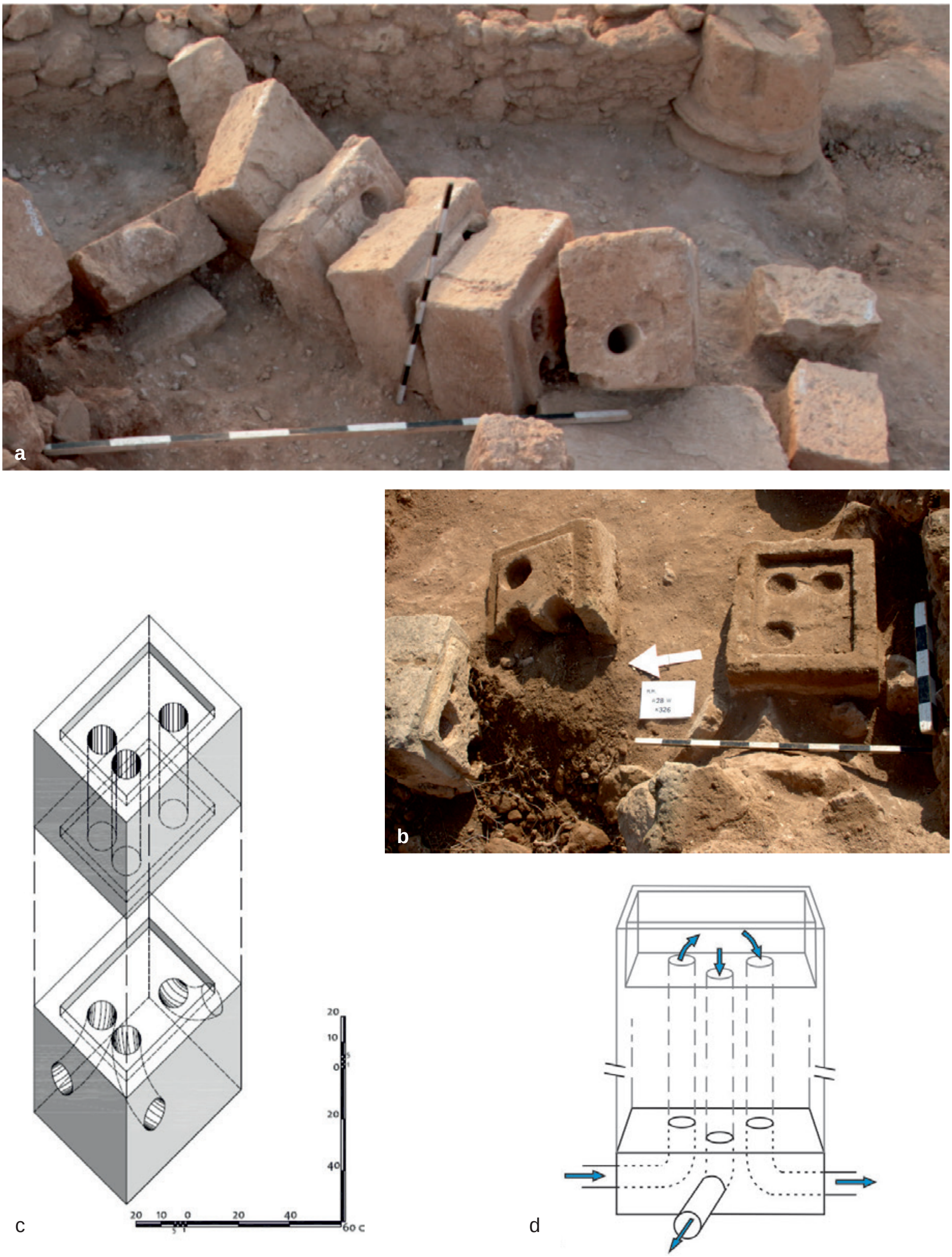
[95] See above, footnote 20.

[96] Daszewski 1994: 108; Meyza *et al.* 2012: 415–416, Fig. 9.

[97] Miszk 2020: 147, 148; Rosińska-Balik 2020: 191; inv. no. S.125. Possibly of similar character was a square block that can be observed in the west wall of north portico of the agora in Amathus. It had two vertical conduits, of which one was leading to the east side, while the second was divided into two branches, north and west, the latter blocked with a stone stopper.

[98] Jansen 2000: 113; Hodge 1996: 271.

[99] Juchniewicz, Żuchowska 2012: 66, Fig. 10; 2013: 346, Fig. 5. For reconstruction of Palmyra water tower, see: Kessener 2020: Figs 5b, 6.



14. Water tower (siphon): a. blocks of siphon found in HH13 (eastern view); b. blocks of siphon found in HH28W (eastern view); c. reconstruction of the siphon tower from HH13; d. reconstruction of the water tower from Palmyra (a-b. Archive of the Polish Archaeological Mission in Nea Paphos; c. drawing: A. Brzozowska; d. drawing: M.M. Romaniuk; based on: Kessener 2020: Figs 5b, 6).

but were made of prefab components, which facilitated their construction and control of the water pressure within the pipeline by reducing or increasing the tower height through adding or removing blocks from its top. These blocks, however, were found at *Maloutena* in a secondary context, thus it can not be said whether and when such devices were originally installed in this area. It is also uncertain if all these blocks constitute a complete set that would allow the reconstruction of the original height of the tower. Nonetheless, it can be assumed at least that they were used within the city at the time in question.

The diameter of the male ends of the investigated spigot-socket pipes was well fitted to the diameter of the conduits cut in the siphon blocks (*c*. 11–13cm). Additionally, the earthenware pipes were also proved to withstand an inner pressure up to 50atm,[100] much more than around 1atm, which would be achieved by differences in height between the hill of *Fanari* (*c*. 20m asl) and *Maloutena* (modern ground level *c*. 10m asl; ancient level *c*. 8–9m asl) and slightly higher from *Fabrika* (*c*. 24m asl).[101] Considering the above, it can be concluded that the early Roman pipelines at *Maloutena* might have been pressurised.

Regarding the pipelines of the late Roman phase, their function seems to be limited to collecting the rainwater and draining it to the cisterns or out of the building. Most of them constituted a water network of the baths. Some were also found in the other spots of VT, however, their late date is questionable (PP34, PP35; **Fig. 9b-c**). To date, despite the large-amount-water-consuming installations in VT, like the assumed nympheum in VT71/72[102] and baths in the south-eastern corner of the building,[103] there was no evidence found for their being supplied with extramural freshwater. One explanation for this can be that the late Roman freshwater lines were not preserved, especially if they were running into the walls like the pipelines in the latrine VT60 (PP28, PP29) or were made of lead.[104] An alternative explanation would be that after the destruction of the earlier freshwater network it was never restored and the area was supplied entirely with water from wells (if existed) and rainwater stored in cisterns. The latter solution is very likely, as numerous bath complexes found elsewhere in Cyprus were also fed mainly with stored

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[100] Forbes 1964: 153. At Priene the terracotta pipes with a wall thickness of 1.5cm – similar to the investigated ones (see **Table 2**) – withstood the atmospheric pressure of 11.5atm (Wiegand, Schrader 1904: 72)

[101] For Digital Surface Model (DSM) of Nea Paphos (Kato Paphos), see: Ostrowski *et al.* 2020: Pl. 144.

[102] Structure interpreted as a nympheum (water fountain) (Daszewski 1998: 11; Daszewski, Michaelides 1988: 53; Medeksza 1992: 41; 1998: 35) consisted of three elongated rectangular basins in the U-shape set around rectangular podium in the western end of the entrance passage (VT71/72), open to the peristyle courtyard of VT (Daszewski 1976: 210).

[103] Apart from the bath in VT, the small bath was also introduced in the south-west corner of the HH, dated so far to the late second and third century AD (Christou 1994: 683; Daszewski 1995: 72). It seems probable, however, that it was built earlier along with the nearby settlement tank/soak pit; see above, footnote 53).

[104] At the sites first occupied by the Greeks the terracotta pipes were preferable over lead ones (Jansen 2000: 119, 121). There are, however, some examples of use of the lead pipes in Nea Paphos, like the one still visible in a basin (south of VT62) in the baths of VT (Daszewski 1976: 202) or by the *proscenium* wall of the theatre at *Fabrika* (see above, page 372, footnote 37). Lead, as a material, was willingly robbed from the sites and reused, especially in the areas where it was scarce, thus lead elements rarely preserved *in situ*.

water.[105] What can additionally support this hypothesis is the appearance of the stone-built cisterns in VT48B[106] and HA15 and the reuse of some Hellenistic ones. Nonetheless, the aqueduct at *Fabrika* was apparently still working to some extent at that time providing water for the nearby Theatre adapted to accommodate the nympheum and water spectacles.[107]

CONCLUSIONS

Examination of the *Maloutena* pipelines shows that their network was well organised, carrying water along the orthogonal streets to the buildings equipped with their own indoor pipeline network. The pipelines were used both for supply and drainage, often joining these functions by draining rainwater to the cisterns. It seems that from the beginning, for the inhabitants of *Maloutena* (and Nea Paphos) the rainwater harvesting (possibly along with the drawing of water from the wells and local streams) was a primary source of water, as the cisterns were used even when the city was provided with an extramural aqueduct. The aqueduct was introduced most likely already in the first century AD or even earlier, in the Hellenistic period, and water could have been distributed over the city through the pressurised pipelines, as is suggested by the relics of the water towers. The abundance of water provided by the aqueduct allowed the inhabitants to equip their houses with water-consuming devices like ornamental pools or baths, hence not objects of necessity but a manifestation of their status and wealth, as well as affinity to Roman culture. As a result of the earthquake that occurred in the first half of the second century AD, this early Roman water infrastructure collapsed, cutting a vast part of the city (or at least *Maloutena* and the agora areas) off from water resources. To date, there is no evidence for a later restoration of this system, thus it appears that afterwards, the inhabitants returned to the water practices preceding the introduction of the aqueduct. This hypothesis raises, however, many questions. Has the early Roman waterworks actually not been rebuilt or simply not survived to the present day? In the first case, why? How would it be possible, that despite the limited water supply, the city began to develop so intensively, of which the most vivid proof was the erection of the VT with its bath complex and other water-consuming devices? These and many other questions should be addressed in further research.

Undertaken studies proved that although the fragmentary state of preservation of the pipelines, a closer examination may provide valuable conclusions on the water management system within the analysed area. It is, however, important to underline that results achieved to date should be treated as assumptions for further verification, whereas the methodology applied should be continuously tested and developed.

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[105] Numerous Roman baths in Cyprus were supplied with water stored in cisterns, e.g. Public Baths on Acropolis and Baths of the House of the Gladiators in Kourion, Gymnasium Baths and Baths next to the Basilica of Campanopetra in Salamis or Baths in the HO in Paphos (see: Christodoulou 2014; see also Rekowska *et al.* 2021, in this volume).

[106] Meyza *et al.* 2011: 284, 289–290, Fig. 5.

[107] Barker 2016.

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Table 1. Morphological characteristics of pipe types discussed in the article

Type	Shape	Fabric
1	M/F form, hourglass body, helically ridged; M: flange slightly flared inwardly, thickened toward the horizontally flat lip of rounded edges, with the rounded shoulder; F: flange flaring outwardly from a pinched up stop, thickened to the horizontally flat lip of rounded edges	1
2	M/F form, hourglass body, helically ridged; M: flange slightly flared inwardly, thickened toward the horizontally flat lip of rounded edges, with the rounded shoulder; F: flange flaring outwardly from a pinched up stop, thickened to the horizontally flat lip of rounded edges	2, 3
3	M/F form, hourglass body, helically ridged; M: cylindrical flange slightly thickened to the horizontally flat lip of slightly rounded edges; F: flange flaring outwardly from a pinched up stop, thickened to the horizontally flat lip of slightly rounded edges	4
4	M/F form, hourglass body, smooth/slightly undulating surface, occ. shallow ridges; M: cylindrical flange slightly flared inwardly, thickened toward the horizontally flat lip, rounded on the edges, with sharp/ rounded shoulder occ. accentuated on the body; F: flange flaring outwardly from a pinched up stop, thickened to the horizontally flat lip of slightly rounded edges	5
5	M/F form, elongated, hourglass body, smooth surface; M: flange slightly flared inwardly, thickened toward the horizontally flat lip, rounded on the edges, with sharp/rounded shoulder occ. accentuated on the body; F: flange flaring outwardly from a built-up stop, thickened to the horizontally flat lip of slightly rounded on the edges	6
6	M/F form, body slightly concave at the ends and belled in the middle (walls thickened here up to 3 cm), smooth, occ. undulating surface; M: flange flared inwardly, thickened to the rounded lips, with the sharp shoulder; F: flange flaring outwardly from a pinched up stop, thickened to the horizontally flat lip of rather sharp edges	7
7	(only one end preserved) thickened rim, body belled at the end and narrowed, cylindrical, helically ridged in the middle	3
8	M/F form, body slightly widened at the M, undulating surface; M: flange strongly concave inwardly, smoothly transformed from the rounded shoulder, thickened to the horizontally flat lip rounded on the edges; F: flange slightly flaring outwardly from a modest pinched-up stop, slightly thickened to the horizontally flat lip of rounded edges	3

M/F – abbreviation for spigot-socket (male end/female end) form of a pipe.

Table 2. Measurements of pipes representing particular types discussed in the article

Type	Number of measured pipes*	Body dimensions (cm)			Male end dimensions (cm)		Female end dimensions (cm)	
		length	**diameter at M/F****	**wall thickness*****	**flange length*****	**flange outer/inner diameter*****	**flange length*****	**flange inner/stop diameter**
1	16	31.3–33.6	14.2–15.2 /14.7–15.3	1.2–1.5	3.4	10.0/8.40	3.4	10.5/10.5
2	21	32.5–40	18.2–19.2 /18–20.5	1.2–1.7	2.7	13.0/10.4	4.2	13.0/12.8
3	17	26.0–31.8	17.5–19 /17.9–18.9	1.7–2.1	4.0	13.8/11.8	3.9	15.0/14.0
4	6	35.0–38.5	15.1–16.5 /15.2–16.5	1.3–1.9	2.8	9.5/7.4	3.8	11.6/11.0
5	4	40.0–44.5	16.2–17.6 /15.8–16.9	1.2–2.0	3.0	12.4/10.4	3	12.8/11.7
6	2	35.8–36.5	15.6–17.2 /15.7–17.4	1.3–2.6	3.0	11.4/8.8	2.9	12.6/11.5
7	1	>49.1	15.3	1.0–1.7	–	–/11.7	–	–
8	1	27.7	14.8/14.2	1.0–1.4	2.2	10.8/8.9	2.5	12.0/11.4

* given measurements are based on the pipes that were preserved sufficiently to measure their full body length and diameter (excluding the pipe of type 7).

** M/F – abbreviation for male end/female end; in case of pipe type 7 it relates to the only preserved end, of thickened-rim type.

*** the presented dimensions were taken from the cross-sections pictured in Fig. 3 to illustrate approximate value, as these were available to measure in the field only in the single cases; in case of pipe type 7 only inner diameter of the only preserved end, of thickened-rim type, is given.

Table 3. Catalogue of the fabrics of pipes discussed in the article

Fabric	Colour	Feeling	Profile break	Hardness	Inclusions	Type of pipe/s
1	core: 5YR6/8; surface: 5YR7/4	harsh	hackly	hard	common medium to large (occ. very large) spherical (occ. tabular) angular (occ. subrounded) brown, dark red, dark grey inclusions; rare small to medium spherical round white (empty inside or of cellular structure) inclusions	1
2	core: 5YR7/6; surface: 2.5YR7/4	harsh	hackly	hard	common medium to very large spherical angular to rounded white, pale grey, dark grey, dark brown and dark red inclusions; rare small to medium spherical round white (empty inside or of cellular structure) inclusions	2
3	core: 2.5YR5/6; surface: 10R7/4, 10R6/6, 7.5YR7/3	harsh	hackly	hard	abundant medium to very large spherical and tabular angular (occ. subrounded) dark brown and dark red inclusions; rare small to medium spherical subrounded dark red and white inclusions; rare small spherical round white inclusions	2, 7, 8
4	core: 7.5YR5/6; surface: 5YR5/4	harsh/ rough	hackly/ granular	hard	abundant fine to medium (occ. to very large) spherical subrounded and angular dark grey, light grey and occ. white and red inclusions	3
5	core: 7.5YR6/3, 10YR6/3; surface: 7.5YR 6/4	harsh/ rough	hackly/ granular	hard	common small to medium (occ. large to very large) spherical angular and subrounded dark grey, dark brown and dark red inclusions	4
6	5YR6/6	rough	hackly	hard	frequent small to medium (occ. large) spherical angular and subrounded pale brown and brown inclusions; common fine and small spherical rounded white inclusions; rare of white round inclusions of cellular structure	5
7	core: 5YR3/4; surface: 7.5YR6/2	harsh	hackly/ granular	hard	abundant medium to very large spherical and tabular angular and subrounded, white, pale brown, dark brown, grey and red inclusions	6

Table 4. Catalogue of terracotta pipelines discussed in the article

Pipeline (PP)	Localisation	Type of pipes	Functional group	Orientation of the course	Flow direction (muff-orientation	Inclination	Dating of the context	Related pipeline/s
1	Street A' (south of RH)	2	I	horizontal, E-W	W	W	mid-first–mid-second century AD	4?
2	Street A' (south of RH9,9W)	a variant of type 2? (same as in PP3 and PP6)	I	horizontal, E-W	E	E	as above	2.1, 3?
2.1	Street A' (south of RH9)	2?	II	vertical	downward	S	as above	2
3	Street A' (south of HH3)	a variant of type 2? (same as in PP2 and PP6)	I	horizontal, E-W	E	E	as above	2? 6?
4	as above	type 2	I	horizontal, E-W	W	W	as above	1?
5	as above	–	I	horizontal, E-W	–	–	as above	–
6	Street A'/HH3	a variant of type 2? (same as in PP2 and PP3)	II	horizontal, N-S	N	N	as above	3?
7	HH3	1	III	horizontal, E-W	E	–	as above	8? 9? 10?
8	HH3/4	1?	III	horizontal, NW-SE	–	–	?	7? 9? 10?
9	HH29/4	1?	III	horizontal, NW-SE	–	–	?	7? 8? 10?
10	HH29	1	III	horizontal, E-W	E	–	mid-first–mid-second century AD	7? 8? 9?
11	HH13	a variant of type 2?	III	horizontal, E-W	E	E	as above	–
12	Street 10/HH32	2	II	horizontal, later vertical, E-W	E, later upward	W	as above	–

Pipeline (PP)	Localisation	Type of pipes	Functional group	Orientation of the course	Flow direction (muff-orientation	Inclination	Dating of the context	Related pipeline/s
13	HH13	–	III	vertical	downward	–	before mid-second century AD	–
14	HH1	–	III	horizontal, N-S	N	–	as above	–
15	HH2	type 1?	III	horizontal, N-S	N?	–	mid-first–mid-second century AD	–
16	as above	–	III	vertical	downward	–	as above	–
17	HH3	–	III	horizontal, E-W	–	–	second/first century BC	–
18	as above	–	III	horizontal, NW-SE	–	–	as above	–
19	as above	–	III	horizontal, N-S	–	–	as above	–
20	Street A (west of VT32)	–	II	horizontal, NW-SE	–	–	?	–
21	as above	–	II	horizontal, NW-SE	–	–	?	–
22	Street A (VT38)	4	I	horizontal, E-W	–	constant	mid-first–mid-second century AD	–
23	Street 9 (south of VT63)	4?	II	horizontal, E-W	–	constant	as above	–
24	Street 9 (unexcavated building to the east, south of VT63)	5	II	horizontal, NW-SE	–	constant	as above	–
25	VT64	–	III	vertical, later horizontal, E-W	downward, later E	vertical, later horizontal, constant	after the fourth century AD (second phase of VT)	27?
26	VT64	–	III	vertical	downward	vertical	as above	27?
27	VT67	–	III	horizontal, SW-NE	NE	NE?	as above	25? 26?
28	VT60 (in the north wall)	8	III	horizontal, E-W	E (in the wall)	constant	as above	–

Pipeline (PP)	Localisation	Type of pipes	Functional group	Orientation of the course	Flow direction (muff-orientation	Inclination	Dating of the context	Related pipeline/s
29	VT60 (in the east wall)	–	III	vertical, later horizontal, N-S	downward, later S (in the wall)	vertical, later horizontal to S	as above	–
30	VT45	–	III	horizontal, N-S	–	–	after the second century AD (after the first phase of VT)	–
31	Street 9 (VT36)	2	I	horizontal, N-S	S	–	mid-first–mid-second century AD	32?
32	Street 9 (VT82)	2	I	horizontal, N-S	S	–	as above	31?
33	Street 9 (VT98)	–	I	horizontal, N-S	S	–	before fourth century AD? (before the second phase of VT)	–
34	Street B (central courtyard of VT)	a variant of type 2? (same as in PP35?)	I	horizontal, E-W	W?	W?	second/third century AD or earlier	35?
35	as above	a variant of type 2? (same as in PP34?)	I	horizontal, E-W	W?	W?	as above	34?
36	Late Roman Street/Street B	–	II	vertical	downward	vertical	after the fourth century AD (after the second phase of VT)	–
37	as above	–	II	horizontal, NW-SE	E, later SE	SE	as above	–
38	VT/Late Roman Street	–	II	horizontal, E-W	–	–	?	–
39	HA1	6 joint with unclassified	III	horizontal, N-S, later E-W	S, later E	S, later E	before fourth century AD	–
40	Street B (south of HA)	3	I	horizontal, E-W	W	W	second–fourth century AD?	–

Pipeline (PP)	Localisation	Type of pipes	Functional group	Orientation of the course	Flow direction (muff-orien-tation	Inclination	Dating of the context	Related pipeline/s
41	Street 9 (west of VT97SW)	–	II	horizontal, E-W	E	E	?	–
42	as above	4	I	horizontal, N-S	S	S	mid-first–mid-second century AD or earlier	43?
43	Street 9/Street C	4	I	horizontal, N-S	S	S	as above	42?
44	Street C (north of VT13E2)	–	I	horizontal, E-W	–	–	?	–
45	VT59 (in the north wall)	–	III	horizontal, E-W	–	–	after the fourth century AD (second phase of VT)	–
46	HH1	7	III	horizontal?	–	–	before mid-second century AD	–

– unclassified within the column 'Type of pipes'; undeterminable in the cases of the columns 'Flow direction' and 'Inclination'.

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