

JOAN BRETON CONNELLY AND ANDREW I. WILSON  
(with mortar analysis by CHRIS DOHERTY)

HELLENISTIC AND BYZANTINE CISTERNS  
ON GERONISOS ISLAND

Reprinted from the

*Report of the Department of Antiquities, Cyprus 2002*

NICOSIA 2002

# Hellenistic and Byzantine cisterns on Geronisos Island

Joan Breton Connelly and Andrew I. Wilson  
With mortar analysis by Chris Doherty

There is no water on the island of Geronisos. There are no springs, and no wells; the only possible means of obtaining water is to bring supplies from the mainland, or to collect rainwater falling on the island itself. Two cisterns, each with an associated impluvium or water catchment platform, are known, both towards the eastern end of the island. They are of different shapes and forms of construction, and evidently belong to different periods, although the earlier (cistern 1) was probably re-used while the later (cistern 2) was in also use (Figs 1, 2). The cisterns were excavated during the 1996 season of the New York University Geronisos Island Expedition.<sup>1</sup> This work followed the trial excavations by Dr Sophocles Hadjisavvas, Director of Antiquities of Cyprus, in 1982.<sup>2</sup> To date, three major periods of occupation have been defined on the island, each separated by long years of abandonment.<sup>3</sup> The Early Chalcolithic period saw the first visitors who left material on Geronisos. Some 3400 years later, the island saw its most intense period of occupation as the site of a sanctuary, probably to the god Apollo, during the last years of Ptolemaic rule in the 1st century B.C. Following the death of Cleopatra in 30 B.C. and the devastating effects of the earthquake of 17 B.C., the Hellenistic sanctuary site was abandoned. Apart from a single burial of the 2nd century A.D., it is not until the Early Byzantine (6th-7th century B.C.) period that we again find evidence for occupation, and this on a relatively modest scale. Limited evidence of activity on the island in the 13th-14th century has also been recovered.

## CISTERN 1

### Structural description

Cistern 1 is a carafe-shaped cistern with an associated paved fan-shaped impluvium (Figs 3,

1. The cisterns were excavated under the direction of J. B. Connelly for the New York University Geronisos Island Expedition during the 1996 season, and were studied by Andrew Wilson, Lecturer in Roman Archaeology, Oxford University, during the 2001 season. We thank Dr Sophocles Hadjisavvas, Director of Antiquities of Cyprus for his generous support and assistance that has facilitated our work in every way. A. I. Wilson has authored the description of the cisterns presented here, their typologies, comparanda and dates, as well as the discussion of the annual rainfall regime and the cisterns' supply. Description of excavation, stratigraphy and finds are written by J. B. Connelly. Mortar analysis has been undertaken by Chris Doherty, Research Laboratory for Archaeology, Oxford, whose report is included here as an appendix. We thank Roger Bagnall for his kind assistance on a number of documentary questions. Plans and sections were drawn by staff architect Andrew Wixom. Photographs were taken by J. B. Connelly, Andrew Wilson and Benjamin Fraker. Fig. 20 was drawn by Mariusz Burdajewicz. The 1996, 2000, and 2001 seasons during which this work was undertaken were funded by the Friends of Geronisos and we thank them for their generosity, particularly James Ottaway, Jr., William J. Murray, Carl S. Forsythe, III and the de Coizart Perpetual Charitable Trust, George Lucas, William R. Rhodes, Nicholas Zoullas, Llyod Cotsen, Henry Luce III and Leila Hadley Luce and Howland D. Murphy. We are further indebted to the John D. and Catherine T. MacArthur foundation for generous support of Prof. Connelly's work during the period of the excavation of the cisterns.
2. S. Hadjisavvas, "An Archaeological survey and Trial Excavations on the Small Island 'Geronisos', off the Pafos Coast," in V. Karageorghis, *Report of the Director of Antiquities of Cyprus* 1983, 39-40.
3. J. B. Connelly, "Yeronisos: Sanctuary of Apollo," *The Explorers Club Journal* 74.1 (1996) 14-8. In this volume: J. B. Connelly, "Excavations on Geronisos (1990-1997): First Report," *RDAC* 2002, and J. B. Connelly and J. Młynarczyk, "Terracotta Oil Lamps from Geronisos and their Contexts," *RDAC* 2002.

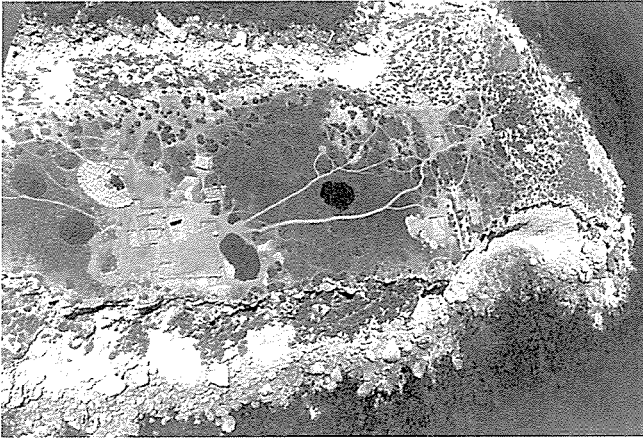


Fig. 1. Aerial view of eastern end of Yeronisos showing cisterns, facing south.



Fig. 2. Aerial view of cisterns, facing south.



Fig. 4. Capstone blocks and intake channel of Cistern 1. Photo: A. Wilson.



Fig. 3. Paved impluvium of Cistern 1, facing north. Pi-shaped wall and enclosure at northwest.

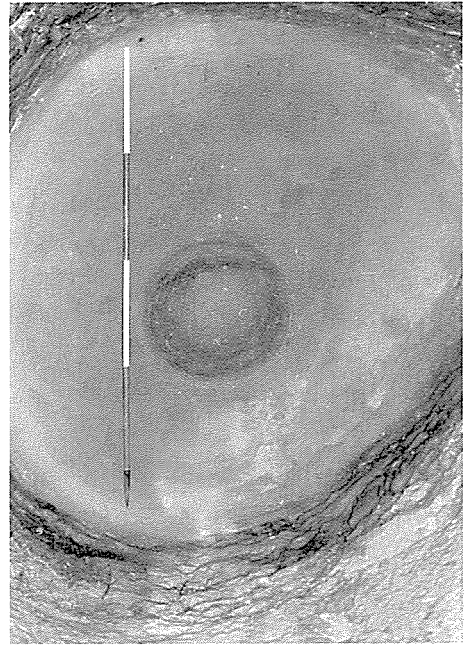


Fig. 5. Interior of Cistern 1 after excavation, showing sump.

6, 7). The cistern is excavated into the calcarenite bedrock but does not appear to penetrate into the marl below. It is roughly conical in shape (Fig. 7), tapering from a diameter of 2.24m. N-S by 2.64m. E-W at the bottom to 1.12m. at the top, and measures 3.64m. deep. The plan is not fully circular, appearing slightly 'squashed' on the S side. A bowl-shaped sump in the bottom of the cistern, 0.71-0.76m. across and 0.35m. deep, was intended to facilitate cleaning (Fig. 5). Capacity is estimated at *c.* 10m.<sup>3</sup>.

Internally the cistern was lined with waterproof mortar, although much has now fallen away. Towards the top the lining mortar is *c.* 1cm. thick, a very light brownish grey tending towards off-white lime mortar with frequent tiny pebble inclusions 2-3mm. across. The surface has been polished smooth. There are traces of yellowish brown water deposits from staining where the water has washed earth containing iron oxides into the cistern.

About halfway down the cistern a large crack splits the bedrock and this, and much of the sides of the cistern below it, has been patched with masonry. This is mortared together with a light brownish white lime mortar with very frequent inclusions of small red, brown, green and grey-blue water-worn pebbles 2-5mm. across, and occasional pebbles 6-10mm. across. Over the structural mortar has been applied a 3cm. thick waterproofing layer of light pinkish brown *opus signinum* that appears to contain fragments of crushed terracotta, and very frequent small pebble inclusions 1-3mm. across. Again, the surface is polished smooth. This mortar appears different from the lining mortar at the top of the cistern, and it is probably significant that it occurs only in the lower part, below the crack in the rock and where the sides have been patched. It is likely that the patching and the mortar in the lower parts of the cistern represent a phase of repair after the cistern had become damaged by the cracking of the rock, perhaps in an earthquake.

The joint between floor and sides is sealed by an angled moulding of mortar applied over fist-

sized stones. This mortar is off-white with tiny pebble inclusions 1-3mm. across, and appears essentially similar to the mortar at the top of the cistern; it may belong to the original phase.

Two of the cistern's capstone blocks remained *in situ*, framing an opening 0.43m. wide (Fig. 4). Cuttings 3cm. wide and 3cm. deep on the inner faces of the upper surface of these blocks appear to have provided a seating for a removable cover, with rectangular sockets at the corners *c.* 6 by 8cm. and 3cm. deep. Two worked blocks each with a rebated groove 3cm. wide and 3cm. deep on one face came from the fill of the cistern and may originally have formed the other edges of the surround of the mouth of the cistern; their dimensions would allow them just to fit in the gap between the two capstones still *in situ*.

The intake to the cistern lay under the NW corner of the western capstone, as a rock-cut channel 0.36-0.38m. wide and 0.25m. deep (Fig. 4). In a second phase rubble blocks were placed in the channel and a layer of mortar applied over them, reducing the channel depth to *c.* 14cm. This is a light greyish white lime mortar with frequent small pebble inclusions 1-3mm. across. It is not clear whether this modification is contemporary with the probable repair to the interior of the cistern.

To the E of the cistern mouth is a paved impluvium constructed of 108 roughly dressed blocks measuring up to 1.28×0.72×0.25m., originally covered with mortar. The blocks were laid in a roughly semicircular formation, around an approximately rectangular core with two circumferential rows tending towards a more circular arrangement (Figs 3, 6). The cistern itself lies somewhat off-centre from the middle of the semicircle, although the intake channel originates near the center. The impluvium or catchment area measured 13.2m. across its greater axis and its surface area is estimated approximately (given the irregular shape) at 70m.<sup>2</sup>.

The blocks had been roughly squared but their surfaces had not been finished and although they had been arranged with care there were nev-

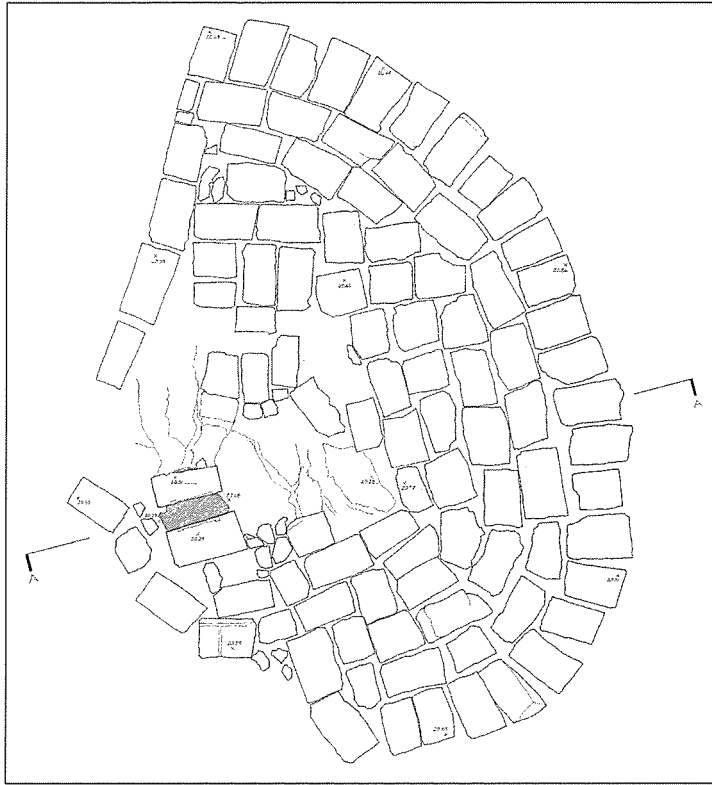


Fig. 6. Plan of Cistern 1 and impluvium (by Andrew Wixom).

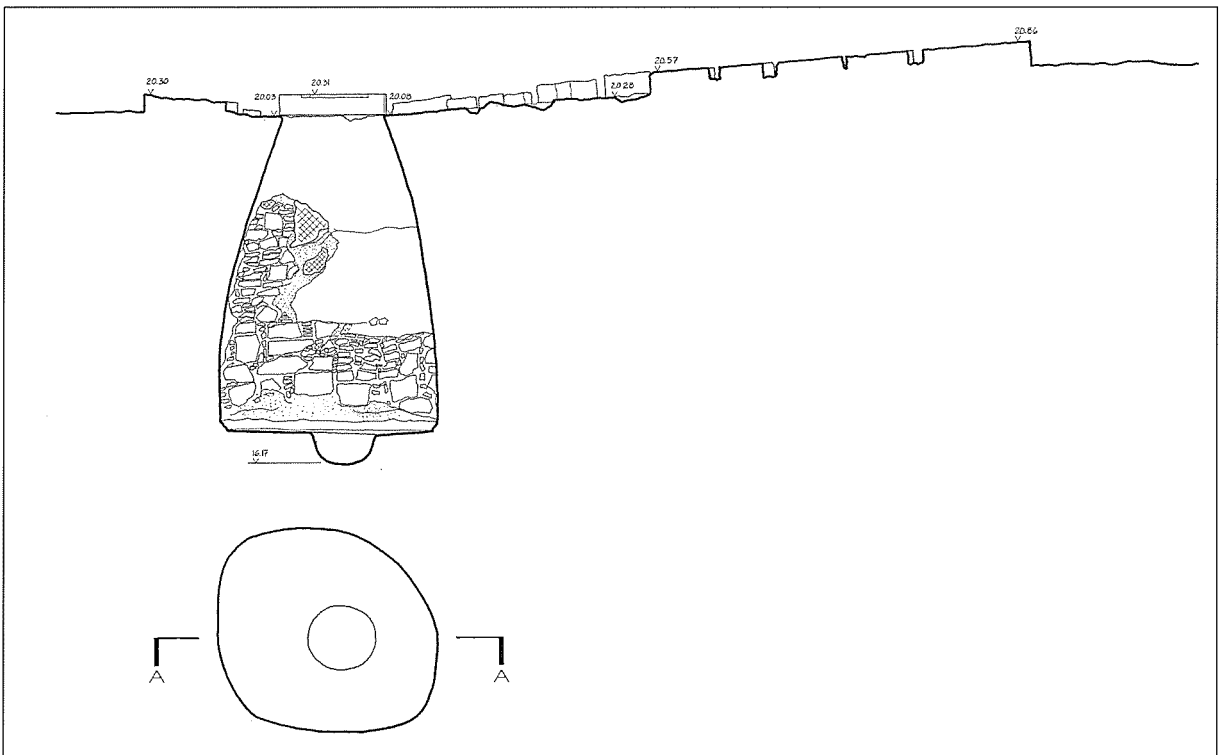


Fig. 7. Section drawing of Cistern 1 (by Andrew Wixom).

ertheless gaps of between 2 and 12cm. between blocks. Originally these would probably have been filled with mortar, and traces of waterproof mortar were extant on the upper face of many of the blocks, which evidently once formed a continuous waterproof surface across the whole catchment area. This mortar, applied as a skin up to 3cm. thick, was a light yellowish white lime mortar with moderate tiny pebble inclusions up to 2mm. across and occasional pebbles up to 1cm. across. Directly to the E of the cistern mouth several blocks are missing, possibly robbed out.

By the W end of the impluvium a small pit c. 0.60m. across cut into bedrock had been used for mixing mortar either for the initial surfacing of the impluvium or a later relining of the inlet channel. Numerous loose small pebbles of the type found as inclusions within the mortar were found in the pit, together with spills of mortar. Pottery found within the pit provided no clear date for the period of the mixing of mortar. It is uncertain whether this operation was associated with the original lining of the impluvium or whether it represents a subsequent repair.

## Excavation

The fill of cistern 1 was excavated on 3-5 June 1996.<sup>4</sup> At the start of work, a dead sea gull, several dead rock doves and a rock dove nest were visible atop the cistern fill, together with quantities of guano. One of the large rectangular blocks from the cistern's impluvium, thrown in from above in recent times, was positioned upon the fill, leaning up against the cistern wall. Carved from the island's local calcarenite stone, the block measures 1.10m. in length, 0.52m. in width, and 0.13-0.16m. in thickness. It shows a smoothed upper surface and rough, pitted lower surface, consistent with the other blocks from the collecting basin.

Following the removal of the bird carcasses and the worked block, excavation proceeded through Level 1.<sup>5</sup> This was a deposit roughly 0.05m. in thickness and comprising greyish-tan

lumpy guano (Munsell 7.5YR7/1) mixed with medium-sized stones that filled two buckets. Level 1 produced quantities of bird and rat bones along with two goat skulls. Local villagers remember the days during British rule when goats and sheep were taken to be hidden in the tall grasses of Geronisos in order to avoid the count by which farmers were taxed on the number of animals they kept. It is possible that the goats belong to this pre-1960, 20th century local practice.

Level 2 consisted of very dark brown earth (Munsell 10.YR22) with some decayed guano, deposited to a thickness of roughly 0.18m. Earth was collected in 102 buckets and sieved. Great quantities of modern bird and rat bones were retrieved. Four large blocks and five buckets of smaller stones were also removed. Among the Hellenistic ceramics recovered were the base of an Eastern sigillata A hemispherical bowl (P.96.50) and the rim of a plain ware trefoil-mouthed oinochoe (P.96.21). Fragments of Combed ware storage amphorae dating to the 6th century A.D. were also found.

This earth overlay Level 3 which comprised a deposit of soft, finer grained orange-black soil (Munsell 7.5YR 3/4) roughly 0.27m. in thickness. Stones were removed in 40 buckets and 80 buckets of earth were sieved. Few bones were recovered. Two large worked blocks showing a rebated groove were removed with this level, measuring approximately 0.21m. in length, 0.175m. in width, and 0.17m. in thickness. These blocks seem to have formed the edges of the surround of the mouth of the cistern. Within this level, two joining fragments of an early Byzantine stamped amphora (P 96.35) and fragments of

4. Excavation was undertaken by J. B. Connelly, George Marshall Peters and Paul Croft.

5. Dead sea gull removed for bone study collection at the Lempa Archaeological Field Unit by Dr Paul Croft who has also undertaken study of the bird and rat bones retrieved from sieving operations of the cistern fill.

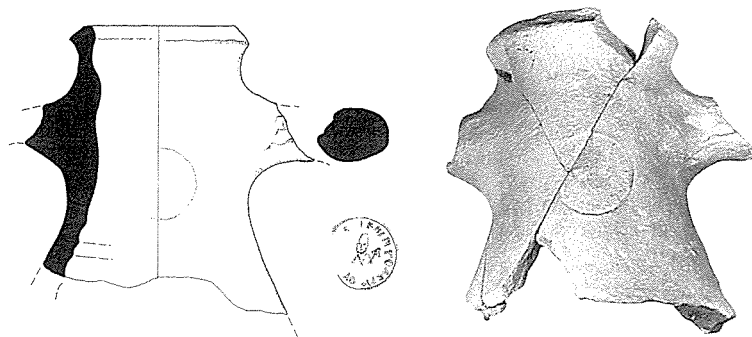


Fig. 8. Stamped amphora from Cistern 1, P.96.35.



Fig. 9. Sgraffito ware bowl, P.96.37.



Fig. 10. Sgraffito ware bowl, P.96.37.

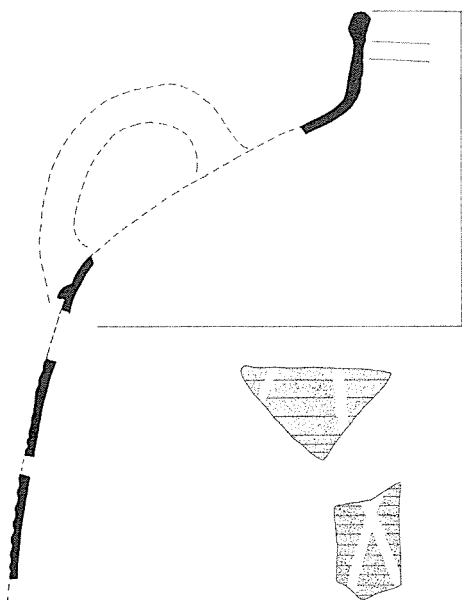
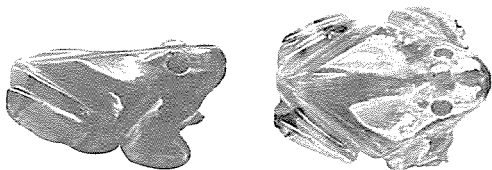


Fig. 11. Beison amphora, P.96.63.



Figs 12, 13. Carnelian frog. Carn.96.01.



Fig. 14. Fragment of limestone triglyph/metope block, StA96.11, from fill to NW of impluvium platform, V40n/V41e.

a large coarse pithos were recovered along with quantities of coarse body sherds and much early Byzantine Combed ware.

Level 4 comprised hard packed gravel mixed with larger stones, very gritty and ranging in colour from white to brownish-red to red (Munsell 7.5YR 5/4). It was roughly 0.42m. thick and yielded 49 buckets of earth for sieving, as well as 5 buckets of small stones and 7.5 buckets of medium sized stones. A rectangular stone basin, broken into seven pieces (St. 96.49) was retrieved. The basin has a maximum preserved length of 0.364m., a width of 0.28m. and a thickness of 0.06m. and is carved from the local calcarenite stone. With the clearing of this level a well-preserved waterproofing layer of light pinkish brown *opus signinum* was revealed, covering the entire floor of the cistern.

The total number of sherds collected from the excavation of Cistern 1 is 282.<sup>6</sup> Of the total, fine wares comprise 10.64%, cooking wares represent 19.5%, while storage and other coarse wares represent 69.5%. The vast majority of the pottery is early Byzantine in date; the remainder is residual. Just one sherd was from the Chalcolithic period. The fill reflects the great mix of materials for the major periods of activity on the island, typical of disturbed earth found across the area. It is clear, however, that the most recent period of use for Cistern 1 was the Byzantine period.

Hellenistic fine ware is represented by two fragments of Eastern Sigillata A, one from a plate and the other from a hemispherical bowl. Local colour coated ware is represented by one fragment of a table amphora, one sherd belonging to a trefoil-mouthed oinochoe and one large bowl fragment. Hellenistic Coarse wares include several fragments of transport amphorae, including a handle, and a few comminuted fragments of cooking pots.

The most diagnostic of the pottery recovered from the cistern dates to the Byzantine period.<sup>7</sup> From levels 3 and 4 six joining fragments of the neck and upper handle of a stamped amphora

were recovered (P.96.35, Fig. 8). The fabric resembles material from the Mareotis region in Egypt. The circular stamp shows the effigy of a man holding a scepter crowned by three balls. Around the interior of the circle an inscription reads in part «ΕΠΙ ΠΤΟΛΑΕ[ΑΙ]ΟΥ» identifying an official under whom the amphora's contents were produced. Although the name Ptolemaios is common in Egypt in every period from the Hellenistic on, there are numerous high-status individuals with this name attested during the period 527-641 A.D. Of these, perhaps the most likely candidate for our Ptolemaios include one who has the epithet *gloriosissimus*, whose heirs are mentioned in a papyrus from Oxyrhynchus.<sup>8</sup> Another Ptolemaios, one who was probably a *magister militum* and mentioned in a papyrus of 599 A.D. is a possible candidate, as is one further Ptolemaios who was an ally of Heraclius in 609 and who appears in the Chronicles of John of Nikiou.<sup>9</sup> With a 6th-7th century date, this important find helps confirm that Geronisos saw activity at precisely the period that the three Early Christian basilicas were built just opposite the island on the mainland at Agios Georgios. Imported from Alexandria, the amphora provides a significant link between Geronisos and early Byzantine Egypt. Further material from the 6th

6. This material is designated as Pottery Lot 22.

7. The identification of the Byzantine pottery has benefited from the contributions of several scholars who have offered analysis either through oral communication or brief written reports. We thank Timothy Gregory who visited in 1995, Henry Maguire who examined the material in 1997, and Jolanta Młynarczyk who studied the material in 2000 and 2001. We are greatly indebted to our colleague, Prof. Charalambos Bakirtzis and his team from the University of Thessaloniki and thank them for their invaluable help in understanding the relationship of our pottery to the material from the basilicas at Agios Georgios, just across from Geronisos on the mainland.

8. Ptolemaios 2 (PLRE III 1069): *P.Oxy.* XVI, 2020.17.

9. Ptolemaios 3 (PLRE III 1069-1070) *magister militum*, BGU I 255.3. Ptolemaios 6 (PLRE III 1070), ally of Heraclius, John of Nikiou, ch. 108.13 (p. 548 Zotenberg). We are indebted to Roger Bagnall for this information.



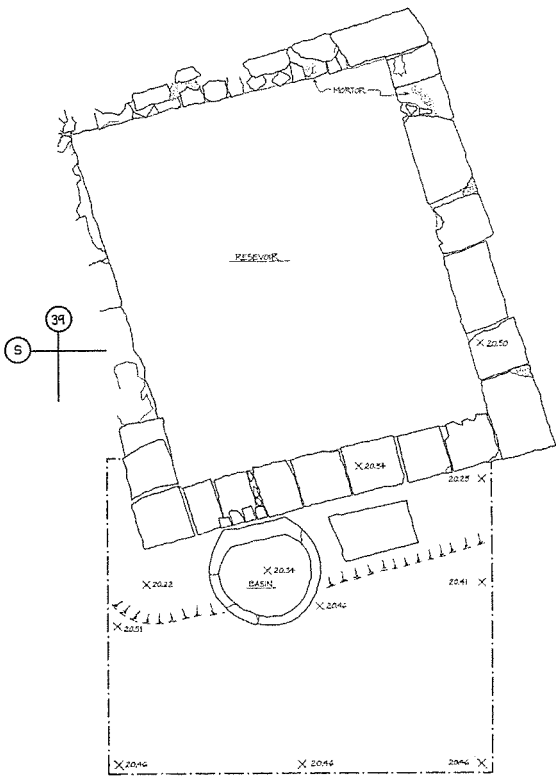


Fig. 15. Plan of Cistern 2.

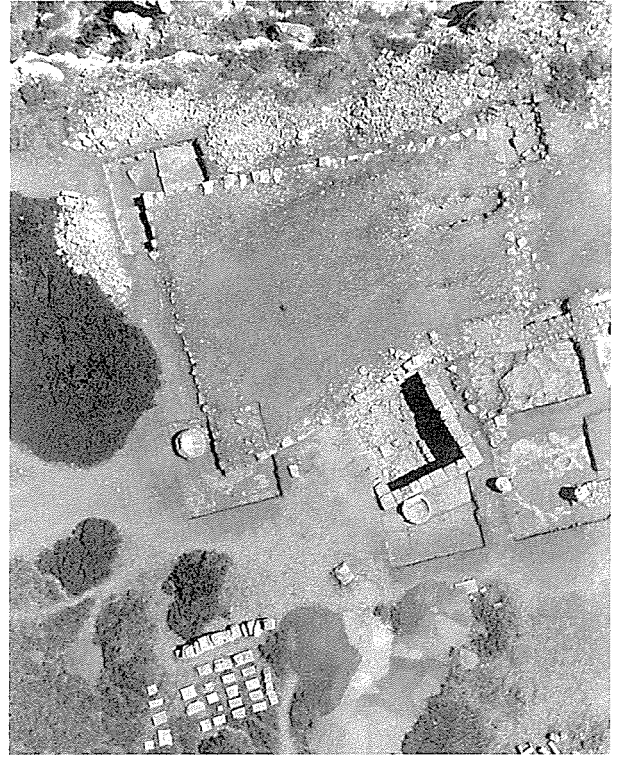


Fig. 16. Aerial view of Cistern 2.



Fig. 17. South-east corner of Cistern 2 showing irregular masonry patching.



Fig. 18. South-east quarter of Cistern 2, facing north. Floor and fill with fallen blocks; top of 7 course section of masonry visible at far left running north-south.

century includes a variety of fragments of combed ware vessels, storage amphorae, and a large coarse pithos fragment.

Sixty fragments of a fine Sgraffito ware bowl of Lempa type (P.96.37) were recovered scattered throughout levels 2, 3 and 4 of the cistern fill (Fig. 9, 10) establishing that these levels essentially belong to a single dumping action. The sherds join together with one fragment recovered from cleaning at the mouth of the cistern and three fragments found well outside the cistern in trench P41-P42/Q41-Q42, level 1.1.1. The joined fragments give a complete profile of a typical brown and green incised Sgraffito ware bowl with vertical rim from the Lempa workshop. This type, with its medium gouged floral decoration is well dated to the first years of the 13th century.<sup>10</sup> A very similar bowl was found on Geronisos during the excavations conducted in 1982 by the Department of Antiquities of Cyprus.<sup>11</sup>

Also from level 4 comes a fragment of a *galaphtiri*, a large coarse ware milking tub of 13th-16th century date (P.96.44). This fragment joins a twisted horizontal handle fragment from well outside the cistern at S 40 2.1.2 (P.96.44), demonstrating, once again the far spread nature of material across the cistern and its surrounding area. A similar *galaphtiri* was found in Hadjisavvas' excavations in one of the three Byzantine houses built roughly in the central western section of the island just at the edge of the great quarry that provided calcarenite boulders for building.<sup>12</sup> The *galaphtiri* fragments attest to the keeping of sheep and goats on Geronisos during the later Byzantine period, a practice that is further attested by the mangers that were constructed within the 6th-7th century A.D. tower houses built beside the quarry and the animal bones collected from within and around these structures.<sup>13</sup>

Level 4 yielded fine and coarse wares of 6th and 13th century date plus one piece of Hellenistic local color coated ware, demonstrating the mixed nature of the fill. In summary, the context pottery from the cistern provides no evidence for the date of construction but suggests that the cis-

tern was repeatedly cleaned out and used well into the Byzantine period, as late as the 14th century.

Two sondages were made near the cistern, one just to the southwest of the cistern mouth at P41-P42n/Q41-Q42s (Fig. 3, 25). This trench was dug in 3 levels, including level 1, a deposit of black topsoil (Munsell 7.5YR 4/3), level 2, a sandy reddish fill (Munsell 7.5YR 4/6), and level 3, a deposit of deep purple/red disturbed terra rosa (Munsell 7.5YR 4/4) just above bedrock. A total of 774 sherds were collected from this trench of which 3.62% represent fine wares, 5.04% represent cooking wares, 88.88% are from storage and other coarse wares and just 2.45% come from Chalcolithic wares.

Among the Hellenistic fine ware fragments recovered was the base of a bowl (P. 96.24), the base of a plate (P. 96.30) and a rim (P.96.28). Some 37 fragments that join the Lempa sgraffito ware bowl that was found within the cistern (P.96.37) were recovered from this area where they were scattered throughout levels 1 and 2. This trench also produced fragments of glass,

10. D. Papanikola-Bakirtzi, "Cypriot Medieval Glazed Pottery: Answers and Questions," in *The Sweet Land of Cyprus, papers given at the twenty-fifth Jubilee Spring Symposium of Byzantine Studies, Birmingham, March 1991* (Nicosia 1993) 115-30, especially pages 118 and 122, plate II d, with example from Lempa in the Pafos Museum. D. Papanikola-Bakirtzi, *Mesaioniki Ephalomeni Ceramiki tis Kyprou: Ta Ergasteria Paphou kai Lapithou* (Thessaloniki 1996), 97-99, cat. nos 97-9 and 102, plates XIX, XX, Fig. V:5. For the Lempa workshop see S. Hadjisavvas, "An Archaeological Survey of Pafos, A Preliminary Report, ERCAC 1977, 227. A. H. S. Megaw and R. E. Jones, "Byzantine and Allied Pottery: a Contribution by Chemical Analysis to Problems of Origin and Distribution," *The Annual of the British School at Athens* 78 (1983), 240-42, 257.

11. Yer.82/31, from Central Complex room A.

12. The house in which the milking tub fragment was found is Room B', as designated by the 1982 excavation effort. The structure was re-excavated by New York University in 1997. The sherd is inventoried as Yer. 82/89. It was studied on 19 May 1995 in the Nicosia Museum storerooms by Tim Gregory.

13. Under study by Dr Paul Croft.

chipped stone, and one very small fragment of what looks like a terracotta sculpture that seems to show hair (TC.96.01).

Just to the north of Cistern 1, a trench was excavated at R41n/S41s (Fig. 3, 25) in order to learn more about the construction of the impluvium as well as to understand better a simple two-course rubble wall that was identified running through several trenches further to the north (Figs 24, 25). This wall encloses an area that may have served as an animal pen, and will be discussed separately towards the end of this paper. R41n/S41s was excavated in four levels, with level 1 comprising topsoil (Munsell 7.5YR 4.3), level 2 made up of a red sandy soil (Munsell 7.5YR 4/4), level 3 comprising a dark red granular earth with many pebble inclusions (Munsell 7.5YR 4), and level 4 made up of the deep red earth of terra rosa deposited just above bed rock (Munsell 7.5YR 4.4). A total of 394 sherds were collected from the trench of which 6.09% were fine wares, 4.57% were cooking wares, and 60.66% were storage and other coarse wares. Chalcolithic wares comprised 28.68% of the pottery recovered. Notable ceramic finds include fragments of a 6th-century local color coated Cypriot Red Slip ware preserving the moulded incurved rim of a bowl with roulette decoration on the exterior (P.96.26). Many coarse amphorae fragments and plenty of combed ware of early Byzantine date were also recovered from the area.

This trench yielded information regarding the construction method of Cistern 1's great fan-shaped impluvium. Excavation along the northern edge of the collecting basin revealed that stones had been deliberately set beneath the impluvium slabs as shims. This enabled the slabs to be set at the best angle from which the basin could direct water flow down to the southwest and into the cistern's mouth. In a second interesting discovery, at the very southwest corner of the trench just beside the impluvium, a deposit of very pebbly soil was found to open onto a naturally formed pit in the bedrock. Within the pit,

very tightly packed pebbles could be seen mixed together with large patches of cement mortar. Construction workers seem to have used the pit as a handy mixing place for the mortar that they used for waterproofing the impluvium. This deposit, which was dug as Level 3.1.3, contained body sherds and one fragment of a handle from a coarse amphora. Unfortunately, these fragments are not diagnostic, and it is unclear whether they date to the Hellenistic period or to a later phase. It is possible that this amphora once held water for the mixing of mortar on the site. Whether this mixing activity dates to the construction phase of the impluvium or represents a later repair is difficult to say. Level 4, the deep red disturbed terra rosa found just above bedrock contained some tile fragments that may belong to a Hellenistic construction phase.

## Dating

Little direct dating evidence for the cistern's construction date was recovered; the interior of the cistern had been regularly cleaned and little material was recovered from the lowest levels of the fill that could date the period of usage, while a sondage beneath two of the slabs of the impluvium yielded nothing to date the construction. The cistern appears to have been filled in or after the 13th century A.D.. Several factors, however, point to a construction date in the Hellenistic period. There must have been water supply provision on the island during all three periods for which we have surviving building remains (Hellenistic, 6th century A.D. and 13th century A.D.). Cistern 2 was constructed and used during the 6th century and Cistern 1 appears to have been repaired and used in both the 6th and 13th centuries. There must have been a water supply for the very robust period of occupation during the late Hellenistic period and Cistern 1 is the best candidate for this, although undiscovered examples may exist. The carafe-shaped form is entirely consistent with a Hellenistic date; it is a widespread form in the ancient world between the 5th centuries B.C. and the 4th century A.D., but is especially common in the Hellenistic world in



Fig. 19. South-east quarter of Cistern 2, intact courses of masonry as fallen into cistern fill.



Fig. 20. Early Byzantine domestic cistern roofed with slabs carried on arched rib walls, at Androna (al-Andarin), Syria. Photo: A. Wilson.



Fig. 21. Detail of sneaked masonry construction at NW corner of impluvium platform for Cistern 2. Plaster floor visible at left against wall.



Fig. 22. Stone tank by Cistern 2.



Fig. 23. Olive mill to SW of Cistern 2 impluvium platform.



Fig. 24. View from impluvium platform facing south showing rubble wall enclosure with re-used column drums.

the second and first centuries B.C.<sup>14</sup> The absence of obviously re-used material in the cistern or its impluvium, and the relatively high quality of the masonry, argue against a Byzantine date for the initial construction and again suggest the Hellenistic period. We can therefore with some confidence ascribe the construction of the cistern and its impluvium to the Hellenistic/Ptolemaic period of occupation on Geronisos, during the first century B.C. The repair and re-lining of the cistern are probably to be dated to the early Byzantine period, given the use of an *opus signinum* type of mortar. The cistern was evidently cleaned and used until its abandonment in or after the 13th century A.D.

## Discussion

The carafe-shaped cistern is a common Hellenistic type, and is well paralleled at sites on Cyprus including Kourion, and further afield at e.g. Olynthos, Pergamon and Morgantina. The capacity of the Geronisos cistern, c. 10m.<sup>3</sup>, is comparable with the smaller domestic cisterns at these sites. However, whereas most similar cisterns are obviously domestic and collected water from the roof and courtyard of the house in which they were built, the Geronisos cistern is not directly associated with any building, and its impluvium had therefore to be specially constructed. We are not aware of any close Hellenistic parallels for the semicircular impluvium, either in shape or construction method. Rural cisterns with rectangular impluvium platforms are however known from Roman North Africa (in northern Tunisia), and such arrangements are still to be found in use on the island of Jerba (southern Tunisia).<sup>15</sup> Rural cisterns with their own impluvia may not have been uncommon in the ancient world, but have rarely been recorded by archaeologists focussing more on urban sites; the Geronisos cistern provides a good example of such a cistern for the Hellenistic period.

The question of who used the water stored in the cistern is bound up with the question of the island's function in antiquity. If anyone lived on the island for any period of time, rainwater col-

lection was the only local source of water, which even then might need to be supplemented by supplies from the mainland. Yet the separation of the cistern from any habitation buildings may suggest that the water was not primarily intended for human consumption; it may have been used for watering gardens and/or a small flock of animals. A few sheep or goats may have been kept here for a short period before sacrifice at the temple or even to provide milk for temple servants in residence. Alternatively, the cistern may have provided water for short-term visitors coming to the island for festivals or to worship at the temple.

## CISTERN 2

### Structural description

Cistern 2 is a rectangular cistern measuring 3.3×3.9×2.85m. deep, giving a maximum capacity of c. 36m.<sup>3</sup> (Figs 15, 16). It is largely

- 
14. Carafe-shaped cisterns are found in Athens in the 5th century B.C., Olynthos in the 4th century B.C., Kourion in the 3rd century B.C., Pergamon (probably 3rd and 2nd centuries B.C.), Morgantina in the 2nd and 1st centuries B.C., and on the Byrsa hill in Punic Carthage before 146 B.C. Carafe cisterns are widespread in coastal Tunisia where they are either Punic or early Roman but in any case continue in use into the Roman period. The latest carafe-shaped cistern of which we are aware is an example of perhaps c. A.D. 400 (though possibly earlier) at S. Giovanni di Ruoti (S. Italy). Athens: Homer A. Thompson *apud* R. Stillwell, 'Architectural studies', *Hesperia* (1933), 126-9. Olynthos: D. M. Robinson, *Excavations at Olynthos* 2 (Baltimore 1930), 56, 72, 100, 110; D. M. Robinson and J. W. Graham, *Excavations at Olynthos* 8 (Baltimore 1938), 307-9 and pl. 76.1; D. M. Robinson, *Excavations at Olynthos* 12 (Baltimore 1946), 118, 287-8 and pl. 101. Kourion: J. B. Connelly, 'A Hellenistic Deposit on the Kourion Akropolis,' *RDAC* (1983) 25-80. Pergamon: G. Garbrecht, 'Die Wasserversorgung des antiken Pergamon', in *Die Wasserversorgung antiker Städte* (Mainz am Rhein 1987), 17. Morgantina: R. Stillwell and E. Sjöqvist, 'Excavations at Serra Orlando. Preliminary report', *AJA* 61.2 (1957), 157. Carthage: S. Lancel (ed.), *Byrsa* 1 (Rome 1979), 77; S. Lancel (ed.) *Byrsa* 2 (Rome 1982), 371 fig. 604. S. Giovanni di Ruoti: A. M. Small and R. J. Buck, *The Excavations of San Giovanni di Ruoti* 1 (Toronto 1994), 77.
  15. Lt Godin, 'Trois installations hydrauliques voisines de Zaghouan', in P. Gauckler (ed.), *Enquête administrative sur les installations hydrauliques romaines en Tunisie* II.2 (Tunis 1903), 69-75. Jerba: personal observation by A. Wilson between 1996 and 2000.

rock-cut, although the upper part is built of two or three courses of re-used ashlar (several evidently originally from a Hellenistic building), with small stones and pieces of tile wedged into the interstices between blocks in typically Byzantine fashion. In the lower parts of the sides areas have been patched with irregular masonry where the friable rock has fallen away (Fig. 17). The larger blocks here show clear traces of bonding mortar – a white lime mortar with very frequent tiny pebble inclusions (greyish blue, grey and brown) 2-5mm. across. Traces of the same mortar adhere to the lower parts of the walls of the cistern and it appears to have served as a waterproof lining mortar as well as a structural mortar. The floor was lined with a very light yellowish brown, almost white, very sandy mortar with moderate inclusions of small grey/blue and white pebbles 3-6mm. across.

Some of the patching appears to belong to a secondary phase, as the more irregular areas of masonry lack bonding mortar, and in some cases patching has been done with smaller blocks that had mortar adhering to them, but which have been wedged in and not mortared to adjacent stones – these blocks are evidently re-used from the original phase.

The cistern appears to have been roofed with flat cover slabs supported on two arched rib walls. The evidence for this came from the fill of the cistern, into which the covering had collapsed. A sondage taken down to the cistern floor in the south-east quarter of the cistern revealed a number of cover slabs *c.* 1.1m. long, numerous squared ashlar and several voussoir blocks including a keystone (Fig. 18). Towards the bottom of the cistern, but still overlying tumbled fill, 7 courses of masonry appeared to have pancaked and fallen in a manner preserving their relationship to each other (Figs 18, 19). These appear to have come from an internal rib wall carried on an arch. The number of voussoir blocks was insufficient to reconstruct a barrel-vault or cross-vault over the cistern, but must derive from an arch rib supporting the flat cover stones. A large block

0.34×0.40×0.78m. may have been a pillar supporting one end of the arch. Cisterns roofed with flat slabs carried on internal arches are quite common in the Eastern Mediterranean, and examples are found from the Hellenistic period (the theatre cistern on Delos) to at least the early Byzantine period (e.g. Syria – Dehes in the limestone massif, and Al-Andarin in the steppe east of the basalt plateau – Fig. 2). As the width of the cistern is 3.3m. and the cover slabs are 1.1m. long, there must have been a second internal support rib in the unexcavated W half of the cistern, dividing the space to be covered into three spans of a little under 1 metre each (allowing for the thickness of the ribs).

One of the cover slabs found within the fill of the cistern had a rebated groove in its upper face, 61cm. long, 13cm. wide and 3cm. deep at one end of which was a rectangular socket 10×6×5cm. deep. This probably served as the seating for a cover, and this block probably formed one side of the opening of the cistern mouth. Another probable cover slab has a channel 5cm. deep and 19cm. wide, tapering to 16cm. wide, across the middle of one surface; this may have formed part of the intake arrangement.

The cistern was fed from an impluvium to the N., in the shape of an irregular quadrilateral measuring 14 and 12m. across its longest axes, with a surface area of *c.* 110m.<sup>2</sup> (Figs 2, 11, 25). If we add the surface area of the cistern itself, the total area available for rainwater collection is *c.* 120m.<sup>2</sup>. The impluvium consisted of a platform of earth and rubble fill *c.* 1m. thick bordered by three courses of roughly dressed blocks with smaller stones packed into their interstices in a technique still seen in Cypriot village stonework (Fig. 21). Against the NW corner a white plaster floor was excavated (Fig. 21).

Adjacent to the south side of the cistern stood a stone tank (Fig. 22), almost D-shaped in plan, measuring 0.68 by 0.79m. internally and 0.39m. deep. Made of the porous local calcarenite, it was lined with mortar, similar to that in the cistern, to make it watertight. Two phases of lining were

evident; the first, 5mm. thick, was a light yellowish white lime mortar with frequent small pebble inclusions 2-5mm. across and moderate terracotta specks 1-2mm. across; the polished surface was discolored by yellowish water staining. The second layer of mortar, also 5mm. thick, appeared visually to be identical in composition. The tank may have served as a drinking trough for animals, or it may have had some connection with the sizable olive mill lying by the SW corner of the impluvium platform (Fig. 23). This mill was a cylinder of local calcarenite, 1.17m. in diameter and 0.48m. thick, with a square socket (10×10.5cm., 4cm. deep) in the center to hold a spindle. An edge runner mounted on this spindle would have crushed olives placed on the upper surface of the cylinder. This type of mill, without a hollowed central basin, is perhaps the simplest type of ancient olive mill, though not necessarily the earliest. There are no immediate parallels cited in Hadjisavvas's study of ancient Cypriot olive oil production (where all examples cited have a hollowed central basin),<sup>16</sup> but a much larger parallel, also apparently late antique or early Byzantine, is to be seen at Sabratha in Libya.<sup>17</sup> The rough surface of the mill, which on first sight appears almost unfinished, is due to weathering; the calcarenite ashlar from the fill of the cistern, which had never been exposed to the elements, were in perfect condition while the surfaces of the cover slabs were heavily worn and eroded.

To the E of the cistern the footings of a rough masonry wall define an irregularly shaped area, with an entrance flanked by two re-used column shafts (Figs 3, 24, 25). Excavation in this area produced much puddled mud probably deriving from a pisé superstructure on the rubble foundations. This area may have been an animal pen.

## Excavation

Cistern 2 was excavated from 6-24 June 1996.<sup>18</sup> At the start of excavation the surface of the fill sloped sharply from northwest to southeast where its level measured roughly 1.80m. below the uppermost course of the water tank.

This sloping of the fill reflected the previous work of digging and dumping in and around the cistern that took place during the 1982 excavations, when Hadjisavvas partly excavated the cistern and the impluvium to the N. The 1996 effort proved to be a most demanding challenge in which roughly 25 tons of worked blocks and fallen stone were removed by hand. In view of the monumentality of the job, a decision was taken to excavate fully in only one quadrant of the cistern, that covering the southeast corner (Fig. 17). The rest will be left for a future season when light weight-lifting equipment can be brought onto Geronisos for safe removal of large stones. This decision was further influenced by the discovery of large sections of intact mortared masonry and blocks from arched rib walls that had fallen in an orderly fashion along an east/west axis through the center of the cistern fill (Fig. 18). With an eye towards reconstruction of the original roofing system, voussoir blocks and substantial stretches of intact masonry were left *in situ* for careful recording and lifting at a future date.

The cistern fill was dug in two levels and partially into a third level throughout the entire structure. Only in the south-east quadrant was the fill dug through a fourth level where it opened onto the smooth waterproof lining mortar of the cistern floor. Level 1 consisted of a dark black topsoil (Munsell 7.5YR 4/3), roughly 0.23m. in depth with many bird and rat bones. Level 2 comprised a mixed ashy and gravelly loose fill (Munsell 7.5YR 4/2) in which a great tumble of worked blocks mixed with mortar and many smaller stones were found. Fragments of broken

16. S. Hadjisavvas, *Olive oil processing in Cyprus: from the Bronze Age to the Byzantine period* (Nicosia 1992), 12.

17. A. Wilson, 'Commerce and industry in Roman Sabratha', *Libyan Studies* 30 (1999), 47-8.

18. Cistern 2 was excavated by Paul Croft and George Marshall Peters. Associated trenches were excavated by Benjamin Britton, Per Chilstrom, Benjamin Fraker, Erin Hayes, Christine Koutnouyan, Brian Shelburne, Marina Thomatos, Laura Wooley, Brigitte Bourgeois, John B. Watts III, and William R. Rhodes.

up Hellenistic limestone mouldings and re-used blocks were recovered. In the northern section of the cistern level 2 measured as much as 2m. in depth, while in the southeast quadrant, where some of the fill had been removed in 1982, the deposit was only 0.50m. in depth. Level 3 was a sandy, gritty earth (Munsell 10YR 6/4) mixed with mortar and a general tumble of blocks including voussoirs and large sections of intact mortared masonry. Level 4 was excavated only in the southeastern quadrant of the trench where it opened onto the waterproofed flooring of the cistern. It was much like level 3, but denser and containing more lime (10 YR 6/4).

A total of 78 sherds were recovered from within the cistern, of which 10.26% represent fine wares, 11.54% cooking ware, 76.92% storage and other coarse wares, and only 1 Chalcolithic sherd. From the Hellenistic period, one Coan amphora handle and two fragments of Eastern Sigillata A were recovered from the fill. The vast majority of fragments are early Byzantine combed wares, with some late Roman amphora fragments (5th-7th century B.C.) and one big coarse pithos fragment. Levels 2 and 4 yielded seven joining fragments of a large black "Beisan" combed ware amphora of a type well attested in northern Palestine (P.96.63, Fig. 11), also dating to the 5th-7th century A.D. These fragments join with 221 sherds from the same vessel that were recovered from well outside the cistern, in trench S39 levels 1 and 2, and in S40 where many fragments were recovered in surface cleaning as well as from levels 1, 2 and 3. The S40w baulk yielded one joining fragment.

Of particular interest are five sherds from at least one early Byzantine coarse ware pilgrim's flask, (P.96.16) retrieved from level 4 just above the cistern floor. This flask was probably dropped and broken while being filled with water from the cistern. Among the other early Byzantine wares are several examples of Cypriot Red Slip bowls with moulded rims and incised roulette decoration including inventoried piece P 96.12. The pottery recovered in the 1996 excavation of Cistern 2 was consistent with that found in Had-

jisavvas' 1982 excavations which similarly yielded sherds from late Roman form 1 amphorae, Cypriot Red Slip ware and other wares dated to the 5th-7th cent. A.D.<sup>19</sup>

Several finds relevant to the cistern's water works were unearthed. A small fragment of a deep red terracotta water pipe was recovered from level 2 (TC.96.03). The shape, size and fabric are similar to that shown by water pipes found 6th century basilicas and baths at Agios Georgios just across on the mainland.<sup>20</sup> The pipe has a diameter of 11cm. and a wall thickness of 0.8cm.

A number of worked limestone blocks that were found within the cistern fill may be connected with the collection and retrieval of water or possibly related to the olive press found nearby in S37-38n/T 37-38s. A square limestone block that may have originally been placed at the mouth of the cistern is pierced through with a finished squared hole that may have been a socket for a cover (StA.96.09). Several blocks related to the arch ribbed walls and roofing of the cistern were also retrieved. These include a keystone block (StA.96.12) and a voussoir (StA.96.15). Several fragments of Hellenistic architectural blocks and mouldings were also retrieved, along with an ashlar block inscribed *eta gamma*, written as a monogram, that is very similar to blocks bearing identical inscriptions found in Hellenistic levels in the central southern complex of the island. One small fragment of a triglyph metope frieze (StA.96.08) of Hellenistic date was recovered here which is identical to other fragments of the frieze found broken up and deposited in the fill around the cistern (Fig. 14). Significant quantities of animal bone, shell, mortar and tile fragments were also recovered from within the cistern.

19. Examined in the Cyprus Museum, Nicosia by Tim Gregory in 1995. Among the 1982 finds are fragments of late Roman form 1 amphorae similar to group K ware in the Athenian Agora and fragments of a late Roman Aegean fabric, datable to the 6th-9th century, relatively rarely found in Cyprus.

20. Oral communication, Prof. Charalambos Bakirtzis.



Eight associated trenches were dug in the area around Cistern 2 and served to define the quadrilateral collection platform that fed into it as well as the space to the west that was enclosed by a modest rubble wall (Figs 16, 25). These trenches include S39, S37-38n/T 37-38s, V37e/V38w, V40e/V41w, T40, T41, S40, S41w baulk and R41n/S41s. The impluvium is roughly polygonal in shape and measures 14m. across its northern face tapering to 13m. at its southern boundary and 12m. on its western face while just 9m. at its eastern edge. The southern edge angles up from both the southwest and southeast corners to meet the edge of the water tank which is set just off center, closer to the southeast corner. The collecting platform stands approximately 0.89m. in height and is made up of an earth and rubble core that is contained by a wall showing three courses of roughly dressed blocks. The masonry is comprised of large stones with smaller rectangular stones set in tight horizontal courses that fill the interstices between the larger stones, a technique known as snecked masonry (Fig. 21). This stonework is typical of the 6th-century building techniques evidenced just opposite Geronisos at the 6th-century basilica complex at Agios Georgios tis Pegeias and to this very day in Cypriot village masonry. Stretches of the platform's retaining wall were revealed in V37e/V38w, S37-38n/T 37-38s, V40e/V41w and T40. The greatest length of wall was exposed at the northeast corner of the platform where a hard-packed white plaster floor was also revealed.

The total number of sherds collected from the cistern and surrounding trenches comes to 6199. Of these 4.23% represent fine wares, 5.71% cooking wares, 54.70% are storage and other Coarse wares and 35.36% are Chalcolithic. The vast majority of the ceramic material recovered dates to the 5-7th century A.D. and to the Chalcolithic period. Hellenistic material is slight and generally very fragmentary and worn. The construction of cistern 2's collecting platform seems to have disturbed a particularly rich Chalcolithic

level along its easternmost side. Chalcolithic material was particularly densely deposited in T41 where 77.90% of all sherds collected were Chalcolithic and in where 76.52% of the total represented Chalcolithic wares. These numbers stand in stark contrast to the situation in S39, just metres away, where a mere 1.17% of the ceramics recovered were of Chalcolithic date. This dramatic variation in distribution of Chalcolithic finds is characteristic on Geronisos where we see intense concentration of undisturbed early material in some places, while a paucity of early material survives from areas that saw widespread building activity in the later periods. The baulk R41n/S41n, level 3.2, yielded a Chalcolithic toggle-shaped picrolite bead, pierced for suspension at one end (St.96.26).

For the Hellenistic period a number Eastern Sigillata A fragments were recovered including those of a bowl, rim, and plate, a full profile of a color coated bowl (P.96.26), two fine local color coated ware jugs, one black glazed sherd, a fragment of a hemispherical bowl and sherds of three fine bowls with incurved rims. One sherd from a fine Delian lagynos was retrieved (P.94.22), very similar to fragments found in the Central South Complex of the island that may represent the residential quarters for Hellenistic pilgrims visiting the sanctuary of Apollo.<sup>21</sup> Hellenistic cooking ware is represented by several fragments of a casserole. One Coan amphora handle and several amphora body sherds were also recovered.

Among the most intriguing finds from the area is a small decorative frog carved from carnelian (Carn96.01, Figs 12, 13) found in trench S 40, level 2.1.1, just beneath topsoil. The stone is pierced for suspension, and most probably once hung from a necklace. This rare piece of personal adornment certainly belongs to the Hellenistic occupation phase of the island and is residual

21. See Connelly and Młynarczyk, *RDAC* (2002).

here, found in this much later context. The charm is exquisitely carved from a rich orange-brown piece of carnelian and most probably came to Geronisos via Alexandria in Egypt. It measures 1.8cm. in length, 1.25cm. in width and 0.05cm. in thickness. A silver pin pierces through the frog's body running lengthwise from the mouth to the backside and would have attached to an implement for suspension.<sup>22</sup> The eyes were drilled for the insertion of another material, possibly silver as well, but the composite material has been lost. Frog amulets are known to have been worn and used by women as fertility charms in antiquity and it is likely that the Geronisos frog was dropped on the island by a pilgrim during the 1st century B.C.

The construction of Cistern 2, its impluvium platform, and surrounding structure involved the reuse of many fragments of Hellenistic architectural members. These include three fragments of blocks from the same Doric triglyph and metope frieze, one of which was found within the cistern and two others found in the fill of the surrounding trenches (StA 96.07, StA96.08, StA 96.11, Fig. 14). None of these preserves an original dimension, though it is clear that the frieze was relatively small in scale and could have belonged to an altar or small installation as opposed to a building. The width of the triglyph section measures just 8.5cm. The largest surviving fragment (StA 96.11, Fig. 14) has a preserved length of 18cm., preserved height of 14cm. and a preserved thickness of 6cm. Several fragments of crowning mouldings, including one with a clear cyma reversa profile, were also retrieved. The two rough and well-pitted calcarenite column drums, set up to define the doorway of the simple rubble walled enclosure, were clearly reused from a Hellenistic structure (Fig. 24). They sit unsteadily in very shallow stratigraphy upon bedrock.

Ceramic finds from the early Byzantine period include fragments of big coarse ware pithoi and amphorae, many of these showing combed decoration, the black Beison amphora, the pil-

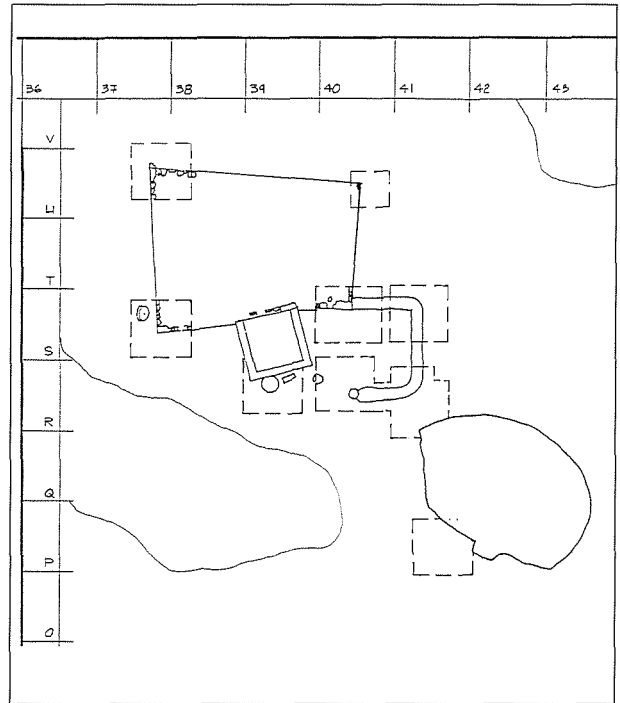


Fig. 25. Plan of trenches around impluvia.

grims' flasks and plenty of Cypriot red slipped bowl fragments, many of which show rouletting (P.96.34). Many small fragments of glass (G.96.39) also date to the 6th century A.D. period of use.

### Dating

The reuse of Hellenistic ashlar in the upper courses of the cistern indicates a post-Hellenistic construction date for Cistern 2, and the fill yielded a quantity of early Byzantine pottery of the 6th century A.D. The cistern's construction and main period of use is probably therefore to be placed in the period of occupation on the island during the

22. We thank conservator Andreas Georgiades of the Cyprus Museum conservation department for his study and analysis of this object.

6th century A.D. As no later material was retrieved from the cistern, it probably collapsed and was filled with debris before the 13th-century period of occupation. The great earthquake of 1160 A.D. is the most likely cause of the collapse of the cistern's roof. The 13th century occupants of Geronisos probably found it easier to clean out the carafe-shaped Hellenistic Cistern 1 rather than the 6th century Cistern 2 which was, no doubt, filled with the heavy tumble of blocks from the collapsed roof.

## Discussion

Cistern 2 evidently served the needs of the island's small community during the sixth century A.D.; but as with the Hellenistic cistern, its separation from known habitation structures of this period leads one to suspect some sort of agricultural use. It may have served for watering animals; for irrigating a small plot of vegetables or a few olive trees; or have provided water for use during oil pressing (to soak the pulp before pressing, and for washing down the premises and press elements after pressing); or several of these functions combined.

### A possible animal pen near the cisterns

From the southeast corner of the impluvium platform, the foundations of a simple two-course rubble wall run some 5m. to the east then turn south to extend 7.5m. before returning to the west for some 4m. in a sort of Pi-shaped line (Figs 3, 24, 25). The wall terminates with a re-used column drum set up at its southwest end and, across an open space of some 2.5m., a second column drum is set up to delineate the entry way for the enclosed space within. Quantities of decomposed pooled mud or pisé were found on the exterior of this wall, particularly densely deposited in T41 which yielded some 35 bags of fragmentary baked clay. This gives firm evidence of a mud superstructure set upon the calcarenite rubble foundations. One fragment of mud preserves the impression of caning and establishes that the roof was made of reed or cane. The enclosure's wide entryway and the humble nature of its construc-

tion indicate that the structure served as a pen or shelter for animals. The fragments of a milking tub found nearby in Cistern 1 and in S40, as well as the quantities of animal bones retrieved from the area, further support this interpretation. The interior of the enclosure contained disturbed levels of mixed 6th century A.D., Hellenistic and Chalcolithic wares. The absence of any later material suggests the 6th century as the most probable period of use. Outside the structure, undisturbed Chalcolithic levels, very rich in pottery, ground stone tools and chipped stone, were preserved intact.

The water supply afforded by Cistern 2 seems to have drawn a great deal of activity to its close proximity. The keeping of animals in the enclosure to the southeast of the water tank was convenient for the feeding and watering of the stock. At the southwest corner of the impluvium, in trench S37-38n/T 37-38s, an olive mill carved in the local calcarenite stone has fallen along a diagonal, perhaps toppled from the platform itself (Fig. 23). This indicates the production of olive oil, again, perhaps dependent on the nearby water supply. Around the cistern, then, we find evidence for food preparation and animal rearing, all on a very small scale. It is difficult to understand why one would go to the trouble of producing olive oil on Geronisos when facilities were available just opposite on the mainland. Perhaps a small grove of olive trees on Geronisos yielded what was regarded as holy oil. A small community of monks living out on the island may have aimed at self sufficiency in food production. This group was active during the 6th century A.D. at the time of the building of the three basilicas across the way at Agios Georgios. That similar activity resumed on the island in some way during the 13th century is evidenced by the *galaph-tiri* as well as a few fragments of Sgraffito ware bowls found in and around cistern 1. Monks are the most likely part-time residents of the island during this latest phase when they seem to have cleaned out and re-used Cistern 1, while Cistern 2 sat filled with debris from its collapse during the 12th century

### The annual rainfall regime and cistern supply

Data provided by the Cyprus Meteorological Authority give monthly rainfall figures for Pafos and Polis, the two nearest monitoring stations to Geronisos, as set out in Table 1. The table gives the average monthly rainfall (in milimeters) over the last 40-45 years, and the actual rainfall for the year 2000. The figures show a characteristically Mediterranean pattern, marked by uneven seasonal distribution and by inter-annual variations; the rainfall in any given year can vary considerably from the average. Most rain falls between October and April, with very little between May and September. This long summer dry season is the critical period for which water has to be stored.

Using the rainfall figures for Pafos (the nearest monitoring station to Geronisos), and knowing the cistern volumes and impluvium areas for

Cistern 1 and Cistern 2, we can calculate how much water could have been collected in each cistern per month (Table 2). These calculations make a number of assumptions, some of which may be less than accurate: first, these are modern figures and we cannot exclude the possibility that the climate varied slightly in antiquity; and secondly that the rainfall on Geronisos is substantially the same as at Pafos (though n.b. the variations between Pafos and Polis in Table 1). Thirdly, some evaporation must be assumed; not all water falling on the impluvia will enter the cisterns, and light rain showers will probably do no more than wet the impluvium surface. Table 2 assumes an arbitrary figure of 30% evaporation. Cistern 1 has a capacity of 10m.<sup>3</sup> and an impluvium area of 70m.<sup>2</sup>; cistern 2 a capacity of 36m.<sup>3</sup> and a collection area of 120m.<sup>2</sup> including the roof area of the cistern itself. On this basis, Cistern 1 could theoretically have been filled twice each year, and Cistern 2 only once.

	Pafos			Polis		
	Average	Actual 2000	% of average	Average	Actual 2000	% of average
January	94.0	85.4	91 %	97.4	108.3	119 %
February	69.0	58.1	84.1 %	73.0	66.1	91 %
March	48.0	39.6	82 %	62.5	46.2	74 %
April	24.0	42.6	177 %	26.5	52.7	199 %
May	7.5	4.3	42 %	13.4	1.1	8 %
June	1.5	0	0 %	1.8	0	0 %
July	0.2	0	0 %	0.8	0	0 %
August	0.2	0	0 %	0.6	0	0 %
September	1.7	20.5	1200 %	2.6	6.3	242 %
October	31.0	16.8	54 %	6.3	22.6	59 %
November	52.0	106.8	205 %	65.0	53.1	82 %
December	98.0	62.1	63 %	99.8	92.8	93 %
<i>Total</i>	427.1	436.2	102.1%	449.7	449.2	99.9%

Table 1. Modern annual rainfall (mm) for Pafos and Polis.

	<b>Pafos rainfall average (mm)</b>	<b>Cistern 1 no evaporation</b>	<b>Cistern 1 30% evaporation</b>	<b>Cistern 2 no evaporation</b>	<b>Cistern 2 30% evaporation</b>
January	94	6.58	4.606	11.28	7.896
February	69	4.83	3.381	8.28	5.796
March	48	3.36	2.352	5.76	4.032
April	24	1.68	1.176	2.88	2.016
May	7.5	0.525	0.3675	0.9	0.63
June	1.5	0.105	0.0735	0.18	0.126
July	0.2	0.014	0.0098	0.024	0.0168
August	0.2	0.014	0.0098	0.024	0.0168
September	1.7	0.119	0.0833	0.204	0.1428
October	31	2.17	1.519	3.72	2.604
November	52	3.64	2.548	6.24	4.368
December	98	6.86	4.802	11.76	8.232
<b>Total</b>	<b>427.1</b>	<b>29.897</b>	<b>20.9279</b>	<b>51.252</b>	<b>35.8764</b>

Table 2. Monthly rainfall supply in m3 to Cistern 1 and Cistern 2.

In practice, of course, things are not quite as simple as that; water is being drawn out of the cisterns each month for use, and we need to consider abstraction rates as well as replenishment rates. The constraint for usage rates is the dry season; the maximum daily abstraction rate can be calculated by assuming that the cistern is full at the start of the dry season, and just about empty by the end. Several iterations of calculation are necessary, as if this daily use figure is then applied throughout the year it becomes evident that the cistern will not be quite full at the start of the dry season, and the calculations need to be repeated for a slightly lower usage figure. Table 3 shows the optimal results of such iterated calculations, with a usage figure of 58 litres per day for cistern 1 and 120 litres per day for cistern 2. By the end of October the cistern is empty or nearly so, and this is probably when the annual cleaning would be done. From November though to March supply exceeds usage and the cistern gradually fills up; from April onwards usage

exceeds supply again and the reserve in the cistern is drawn down over the dry season, emptying the cistern by the end of October.

These calculations are of course approximate, and assume also that usage remains constant throughout the year, when in fact demand for water is likely to have been higher in the hot dry season. Nevertheless, they illustrate possible scenarios for usage of the cisterns, and show that in an 'average' year neither cistern will ever have been full to the brim – although the extra capacity could have been filled in a wetter than normal year. Having established possible daily usage figures, we can estimate how many people could have been supplied by each cistern if they were living on the island all year round and using the cistern as their only source of supply. World Health Organization data suggest that a minimum of 5 litres per person per day is necessary to sustain health (for drinking and washing); we might assume a figure of 10 litres per person per day. On that basis cistern 1 could support just

	<b>Cistern 1</b>	<b>Remaining at</b>	<b>Cistern 2</b>	<b>Remaining</b>
	<b>supply</b>	<b>end of month</b>	<b>supply</b>	<b>at end</b>
				<b>of month</b>
November	2.548	0.808	4.368	0.768
December	4.802	3.87	8.232	5.4
January	4.606	6.736	11.28	13.08
February	3.381	8.377	8.28	17.76
March	2.352	8.989	5.76	19.92
April	1.176	8.425	2.88	19.2
May	0.3675	7.0525	0.9	16.5
June	0.0735	5.386	0.18	13.08
July	0.0098	3.6558	0.024	9.504
August	0.0098	1.9256	0.024	5.928
September	0.0833	0.2689	0.204	2.532
October	1.519	0.0479	2.604	1.536
Usage per month (litres)		1740		3600
Usage per day		58		120

Table 3. Estimated storage volumes in m<sup>3</sup>, fluctuating over the year. The figures for supply are based on figures from Table 2 (at 30% evaporation), and usage is calculated at a rate that would nearly empty the cistern by the end of the dry season.

under 6 people, and cistern 2 could support 12. But in reality these cisterns may have been used more for agricultural purposes instead of or as well as human supply –to provide water for a few sheep or goats, to water a few trees or a small vegetable plot, and (in the case of Cistern 2) for the olive pressing activities implied by the adjacent olive mill. Obviously these other needs reduce further the human population that could be supported all year round on the island. However, it is possible –even likely– that other cisterns remain undiscovered; one would expect water for drinking to have been collected closer to habitation structures rather than at the opposite end of the island, and it seems probable that there would have been cisterns associated with the known Hellenistic habitations in the western half

of the island, collecting water from their roofs.

Despite the various uncertainties and approximations in the foregoing discussion, the picture derived from study of the water supply arrangements suggests that if there were any year-round population on the island, it is unlikely to have been larger than a small family or a handful of people. Possible scenarios might include, in the Hellenistic period, a couple of priests and small group of attendants for the presumed sanctuary; or, in the 6th century and again in the 13th century, a small community of monks, perhaps with a few sheep or goats. Alternatively, residence on the island may have been seasonal and there may have been no permanent population. The cisterns may thus have served the needs of occasional visitors to the island, coming for religious festivals.

## GERONISOS ISLAND PROJECT - MORTAR ANALYSIS

Chris Doherty

*Research Laboratory for Archaeology, Oxford*

## 1. Background

Twelve samples described as mortars from the Geronisos Island Project were submitted for analysis. The mortars are from two related cisterns and represent both structural material and waterproof linings. The purpose of this analysis was to produce an overall characterization of the material and to answer the following specific questions:

- a) what are the differences between the structural and lining mortars?
- b) why is the lining mortar waterproof?
- c) what are the differences and similarities between the two cisterns?
- d) is the impluvium mortar of the structural or waterproof type?

## 2. Sample details

<i>Lab ref/ID</i>	<i>Location</i>
AW1/Sample 1	Cistern 1 - Mortar sample from overpatching in lower part of cistern
AW2/Sample 2	Cistern 1 - Moulding at bottom
AW3/Sample 3	Cistern 1 - Mortar from over rock in upper part of cistern
AW4/Sample 4	Cistern 1 - Structural mortar from patching about 2/3 way down east side cistern
AW5/Sample 5	Cistern 1 - Lining mortar from over sample 4
AW6/Sample 6	Cistern 1 - Mortar from top of impluvium
AW7/Sample 7	Cistern 1 - Mortar from intake channel
AW8/Sample 8	Cistern 1 - Sample from impluvium to SW of intake channel
AW9/Sample 9	Cistern 1 - Mortar sample - loose among blocks of impluvium
AW10	Cistern 1 - Surface find - cistern 1 impluvium
AW11/Sample 1	Cistern 2 - from within cistern
AW12	Cistern 2 - Plaster from SW corner of impluvium

## 3. Findings

Two types of mortars could be easily distinguished by binocular microscope examination of sawn surfaces of these samples.

The structural (S-type) mortar comprises rounded grains of quartz, chert/flint and metamorphic rocks in a lime matrix. The grain size of these inclusions does not vary much and does not exceed 3-4 mm. Very little fine material is present in this mortar type and large irregular voids may be common.

The waterproof (W-type) contains similar inclusions but also has an additional component. This is a significant proportion (5-10 wt%) of angular fragments of brick or tile. These occur both as coarse fragments (up to a maximum of 1-2mm.) and as very fine material dispersed throughout the lime matrix, to which they impart a pale pink colour. The occurrence of these two mortar types is summarised below:

<i>Ref.</i>	<i>W-type</i>	<i>S-type</i>	<i>Comments</i>
AW2	+	+	Outer W-type layer on S-type
AW3	+	+	Outer W-type layer on S-type
AW4	+	+	Thin layer of W and S-types on masonry (beachrock)
AW5	+	+	Outer W-type layer on S-type
AW6	+		Thin fragment showing W-type only
AW7	+		W-type only, directly applied to masonry (beachrock)
AW8	+		Very small fragment, W-type
AW9	+		W-type but becoming very poorly consolidated to rear
AW10			Not a mortar sample; masonry (beachrock)
AW11	+		W-type but distinct from cistern I as higher sand content
AW12	+		As AW11 i.e distinct from cistern 1, but less uniform sand distribution

#### 4. Comments

To return to the original questions proposed at the outset:

a) What are the differences between the structural and lining mortars?

Both are lime mortars using the same sand, a beach sand comprising very well rounded grains of metamorphic rocks, chert and lesser quartz. In addition, the lining mortar contains a significant amount (estimated 5-10 wt%) of crushed brick or tile. In contrast to the sand fraction this is very angular in shape and consists of both coarse (1-2 mm.) material and fines. The latter give a pinkish colour to the matrix.

b) Why is the lining mortar waterproof?

The crushed brick acts as a pozzolan giving a much stronger degree of bonding between the sand and lime. The result is a stronger and denser mortar with fewer shrinkage cavities. Pozzolanic cements were favored for these situations because of their ability to harden in permanently wet conditions. Natural pozzolans such as volcanic ash were favored, but substitutes such as crushed brick or tile were used in non-volcanic regions.

c) What are the differences and similarities between the two cisterns?

Cistern 2 is only represented here by 2 samples but it appears to have used a poorer quality lining mortar. The sand fraction is the same but in one of the samples this is very poorly mixed with the lime.

d) Is the impluvium mortar of the structural or waterproof type?

The impluvium mortars are the waterproof lining type (W-type).



## ΠΕΡΙΛΗΨΗ

Στο νησί της Γερονήσου δεν υπάρχει νερό. Προς την ανατολική άκρη του νησιού έχουν ανασκαφεί δύο δεξαμενές νερού, συνδεδεμένη η κάθε μια με πλατφόρμα συλλογής ύδατος. Οι δεξαμενές αυτές δεν είναι ιδίου σχήματος και κατασκευής και προφανώς η κάθε μια ανήκει σε διαφορετική χρονική περίοδο, αν και η παλαιότερη (Δεξαμενή 1) είχε πιθανόν επαναχρησιμοποιηθεί κατά τη διάρκεια της λειτουργίας της δεύτερης (Δεξαμενή 2). Οι δεξαμενές ανασκάφτηκαν το 1996, κατά τη διάρκεια ανασκαφικής περιόδου της αποστολής New York University Yeronisos Island Expedition, υπό την διεύθυνση της Καθ. Joan Breton Connelly.

Η Δεξαμενή 1, έχει σχήμα καράφας και είναι επιχρισμένη με υδραυλικό κονίαμα. Η χωρητικότητά της υπολογίζεται στα 10 περίπου κυβικά μέτρα. Τροφοδοτείται από ένα πλακοστρωμένο *impluvium* το οποίο αποτελείται από 108 αργούς λίθους, και το μέγιστό του μήκος είναι 13.2 μ. Ενώ δεν γνωρίζουμε άλλα παράλληλα παραδείγματα για το *impluvium* σε σχήμα τεταρτημόριου εν τούτοις η ίδια η δεξαμενή σε σχήμα καράφας χρονολογείται στην Ελληνιστική περίοδο. Η δεξαμενή είχε επανελημμένα καθαριστεί και η χρήση της προχωρά μέσα στον 14<sup>ο</sup> αιώνα μ.Χ. Μέσα στην επίχωσή της βρέθηκαν όστρακα από κούπα της εγγάρακτης (sgraffito) κεραμικής της Λέμπας, μαζί με αρκετά όστρακα ενός γαλευτηριού (δοχείο για το γάλαμα, τραχείας κεραμικής του 13<sup>ου</sup>-16<sup>ου</sup> αι.) και μια σφραγισμένη λαβή αμφορέα της πρώιμης Βυζαντινής περιόδου από την περιοχή Mareotis της Αιγύπτου.

Η Δεξαμενή 2 είναι ορθογώνια και οι διαστάσεις της είναι 3,3×3,9×2,85μ. Η χωρητικότητά της υπολογίζεται στα 36 κυβικά μέτρα περίπου. Το μεγαλύτερό της μέρος είναι κτισμένο στον βράχο, αν και το ανώτατό της σημείο είναι χτισμένο με δύο ή τρεις σειρές από επαναχρησιμοποιημένους, λαξευτούς λίθους Ελληνιστικής περιόδου. Το πάτωμα ήταν επιχρισμένο με ένα πολύ ελαφρύ και αμμώδες κονίαμα. Η δεξαμενή φαίνεται να ήταν στεγασμένη με επίπεδες πλάκες οι οποίες στηρίζονταν πάνω σε δύο ραβδωτούς καμαρωτούς τοίχους. Στην επίχωμάτωση βρέθηκαν αρκετοί ογκόλιθοι *voussoir*, μεταξύ των οποίων και ένα κλειδί αψίδας. Βρέθηκαν επίσης και όστρακα χτενιστής Βυζαντινής κεραμικής, Υστερο-Ρωμαϊκοί αμφορείς (5<sup>ου</sup> και 7<sup>ου</sup> αιώνα π.Χ.), ένας μεγάλος αμφορέας τύπου "Beisan" από την Παλαιστίνη, πολλά ερυθρόχριστα κυπριακά κύπελλα με εγγάρακτη οδοντωτή (roulette) κόσμηση, και δύο φλασκιά προσκυνητών, τραχείας κεραμικής. Η κατασκευή της δεξαμενής, και η κύρια περίοδος χρήσης της πιθανόν να χρονολογείται στον 6<sup>ο</sup> αιώνα μ.Χ. Μεταγενέστερο υλικό δεν ανευρέθηκε μέσα στη δεξαμενή, γεγονός το οποίο πιθανόν να υποδεικνύει ότι αφού κατέρρευσε, η δεξαμενή γέμισε με υλικό προερχόμενο από την περίοδο πριν από την κατοίκηση της Γερονήσου, τον 13<sup>ο</sup> αιώνα. Η πιο πιθανή αιτία κατέρρευσης της οροφής της δεξαμενής είναι ο μεγάλος σεισμός του 1160 μ.Χ.

Τη Δεξαμενή 2 τροφοδοτούσε ένα *impluvium* στο Βορρά το οποίο έχει το σχήμα ακανόνιστου τετραπλεύρου με μετρήσεις 14 και 12μ. στις μακρύτερες του πλευρές και με επιφάνεια περίπου 110 μ<sup>2</sup>. Το *impluvium* αποτελείται από πλατφόρμα με γέμιση από χώμα και μπάζα, και συνορεύει με τρεις σειρές από αργούς λίθους αρμολογημένους με μικρά χαλίκια, τεχνική γνωστή ως χαλί-κωμα.

Η μελέτη της οργάνωσης της παροχής νερού στη Γερόνησο, μας δείχνει ότι, εάν υπήρχε πληθυσμός ο οποίος διέμενε στο νησί ολόχρονα, δεν θα ήταν μεγαλύτερου αριθμού από μια μικρή οικογένεια ή μια χούφτα ανθρώπων. Κατά την Ελληνιστική περίοδο ίσως να διέμεναν εκεί μερικοί ιερείς και μικρός αριθμός πιστών. Στη συνέχεια, κατά τον 6<sup>ο</sup> αιώνα και ξανά πάλι τον 13<sup>ο</sup> αιώνα, μια μικρή κοινότητα μοναχών ίσως να έμενε στο χώρο, μαζί με μερικά πρόβατα ή κατσίκια. Εναλλακτικά, η διαμονή στο νησί θα μπορούσε να ήταν εποχιακή και έτσι να μην υπήρχε μόνιμος πληθυσμός. Έτσι, οι δεξαμενές ίσως να εξυπηρετούσαν τις ανάγκες περιστασιακών επισκεπτών, οι οποίοι να καταφθάναν στο νησί για να πάρουν μέρος σε θρησκευτικές γιορτές.