Water management in Minoan Crete, Greece: the two cisterns of one Middle Bronze Age settlement

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Abstract
The two earliest structures of Minoan Crete that may be considered as large cisterns were both built in the first half of the second millennium BC (the time of the first Minoan palaces) at Myrtos-Pyrgos (Ierapetra). A considerable feat of engineering and social management, they remain a most unusual attribute of a Minoan settlement, all the more so since the Myrtos river is/was available to supply water at the foot of the hill of Pyrgos. This paper presents these cisterns, briefly, in terms of geology and technology, the history of their use and re-use, and their relevance to understanding the culture and society (at local and regional levels) of Crete in the time of the Old Palaces, as well as their possible contribution to the political and military history of the period. I then review possible precursors of, and architectural parallels to, the Pyrgos cisterns at Knossos, Malia and Phaistos (none of which has been proved to be a cistern), and the later history of cisterns in Bronze Age Crete. Since only three others are known (at Archanes, Zakro and Tylissos, of Late Bronze Age date), the two cisterns of Myrtos-Pyrgos are an important addition to our still rudimentary knowledge of how the Bronze Age Cretans managed their water supplies.

Keywords Cisterns; Crete; Middle Bronze Age; Minoan culture; Myrtos-Pyrgos

Introduction
The small Bronze Age (BA) settlement of the Minoan culture at Myrtos-Pyrgos (Ierapetra) on the S coast of East Crete had a long, if occasionally intermittent, life from the Early Minoan (EM) II period (c. 2900–2300/2150 BC) to the Late Minoan (LM) I (c. 1700/1650–1450), with a few signs of use both before EM II and after LM I. The history of the hilltop settlement, which measures some 90 × 65 m to give an area of somewhat over 0.5 ha, has been divided into four principal phases: Pyrgos I-IV. The third of these (Pyrgos III) belongs to the later part of the period of the Old (or First) Palaces of BA Crete, otherwise known as Protopalatial, and may be dated c. 1800–1700/1650. During Pyrgos III a remarkable group of monumental structures was built for and by the presumably small community centred at this site. Among them are two large plastered cisterns that are the earliest known — and universally recognised as cisterns — from the Minoan culture (Cadogan, 1978; 1992). These tanks storing storm water represent a considerable, and in one instance perhaps foolhardy, feat of engineering as well as of social management — and remain, since their discovery in the early 1970s, a most unusual attribute of a Minoan settlement, all the more so since the Myrtos river is/was available to supply water at the foot of the Pyrgos hill. One must note, however, that it is just possible, but unlikely I believe, that the smaller Cistern 1, set in a courtyard on the top of the hill, may have been a granary.

The two cisterns

Situation
The hill of Pyrgos rises to 77.63 m ASL immediately E of the mouth of the Myrtos river, and across the river from the modern village of Myrtos (to the W). The hill is steep on its SE, S and W sides, but more accessible from the inland-facing N. The top of the hill
however, the locus of the Minoan settlement, is steep on all sides, but the summit is relatively flat and was tilled until around 50 years ago. The hill is formed principally from marl strata interceded with laminated sands (Gifford, 1992). Given its steepness and permeability, the hilltop location of the Minoan settlement is utterly unsuited for digging wells. The most convenient water supply would have been the Myrtos river below, although its exploitation would have demanded a considerable supply of labour and/or donkeys to bring the water up the hill. Although the river collects water from a large basin on the S side of the Lasithi Mountains, it only flows nowadays down at Myrtos in the rainy winter months. Its apparent drought in the rest of the year may be attributed to the many boreholes and wells that have been dug in the valley for irrigation. We may assume, however, that this was not the case in the past, when the river flowed probably for (nearly) all the year, while wells in the valley floor could have supplied any shortfall. Certainly there was enough water, probably brought by aqueduct from a few km up the valley, to supply a Roman bathing establishment, probably dateable to the 2nd century AD, immediately to the W of Myrtos village. When it rains, the precipitation often comes as intense downpours that can cause flash floods in the river, even today. (As for the past, it is noticeable how strongly the upstream quoins were built for a late 19th century bridge crossing the river about 1 km inland.) Similarly on the Pyrgos hill, the rainwater collects suddenly and runs down the slopes vehemently during these storms, eroding the BA buildings that are now exposed through excavation. The rain would have been quite as damaging in BA times.

The cisterns

The two cisterns of Myrtos-Pyrgos (Cadogan, 1992: 203–205, Figs. 28.1–28.2) (Figure 1) are similar in construction and date. On the evidence of the sherds of ceramic storage jars (that would have been used for collecting the water) found in the bottom of each, their (first) use was in the Pyrgos III phase – or just possibly a little earlier, even late Pyrgos II.
Both cisterns are circular (but see below on Cistern 2) and have vertical walls and a rounded bottom, where the last drops of water could collect in the concavity. Walls and bottom are coated with white lime plaster 1–2 cm thick. On the cistern bottoms the plaster was applied over a bedding of small river pebbles, on the walls against roughly hewn stone blocks. Neither cistern has evidence of any roofing or of supports (such as stone pillars) for awnings to prevent evaporation. However, it would not have been difficult to stretch awnings over them.

Cistern 1. Cistern 1 (Cadogan, 1978: 71, Fig. 3: D, 74, Fig. 10, 78–79, Figs. 21–22; 1992: 204–208, Figs. 28.1–28.2, 28.5–28.6) is the smaller of the two, measuring about 3.42 m in diameter with a maximum depth, as far as we could estimate (since excavating was dangerous), of 2.48 m to the bottom of the central concavity. This gives a capacity of approximately 22 tonnes. We cannot yet ascertain how storm water was channelled into this cistern in the Pyrgos III phase, but that would have been fairly easy – indeed it could have flowed there naturally – since the cistern is set some 5 m below the peak of the hill in the flat paved courtyard on the S front of the imposing Country House, which was the central building of the LM I (Pyrgos IV) settlement. As the cistern dates to Pyrgos III, the courtyard was necessarily laid out then – if not yet earlier. In all events, it is older than the Country House. If, as is likely, there was already a Pyrgos III central building on the site of the later Country House (Cadogan, 1997; forthcoming a), the cistern would have collected storm water from it. Cistern 1 is, to the best of our knowledge, intact; but we excavated only one quarter of it, for safety reasons. It is just possible that this cistern was in fact a granary (as has been suggested for various round structures at Knossos, Malia and Phaistos [see below]), but improbable. Why? Because, being below the top of the hill with its central building, it would have been hard to stop the water running into it when there was a storm – which would have spoilt the grain.

Cistern 2. Cistern 2 (Cadogan, 1978: 71, Fig. 3: E, 74–75, Fig. 11; 1992: 204–206, Figs. 28.1–28.2, 28.4) is a much larger structure. Far less well preserved, it was excavated completely. Its walls form an irregular circle with a pronounced bulge to the W – and irregular diameter of approximately 5.3 m. As for its height/depth, we do not know if some top courses of stones are missing; but we can say that the cistern was at least 3 m deep. This gives a minimum capacity of approximately 66 tonnes. A number of rectangular and U-section open drains, gutters and spouts, some of them like those from Akrotiri on Thera (Palyvou, 2005: 39–40), could have channelled water off roofs towards and into this cistern: these finds need further study. Cistern 2 lies some 12 m below the top of the hill at, or very close to, the edge of the settlement. It is partly built into the slope of the hill, and partly would have projected up from it on the downslope side. While it was well placed to receive stormwater coursing down the hill in volume, it was a precarious position to hold such a weight of water. It is not surprising that the cistern broke at some time: the downslope wall fell away, and there is some splaying of the stones that are still in situ at its NW side (the lowest point of the cistern wall), which may be the result of the force of the water spilling out – if, of course, there was water in the cistern at the time of the disaster. This probably happened in Pyrgos III, and certainly before two higher-level walls were built, partly over the ruined wall of the cistern, during LM I (Pyrgos IV).

Immediately upslope from the cistern to the SE and S are two formidable terrace walls that must be of Pyrgos III date, one of them very well preserved (Cadogan, 1978: 75, Fig. 11). These walls had probably both a defensive purpose – to repel attackers at the settlement’s most vulnerable point, while providing military cover for the cistern – as
well as the structural one of supporting upslope buildings. A few metres to the SW, at the end of the principal terrace wall, is a tower-bastion that would also have had a defence function.

Communal and regional contexts
In view of the presumed continuing availability of water in the river valley in the MBA, the decision of the Protopalatial “authorities” (whoever they may have been) at, or for, Pyrgos to invest a considerable amount of labour in constructing these two monumental cisterns of a total capacity approaching 90 tonnes, and even setting one of them in an inherently unstable position on the slope of the hill, needs scrutiny.

Explanations may include local causes or relate to regional or island-wide issues, or a combination of such factors. At local level, one could posit perhaps an onslaught of malaria down in the valley. But it would be unlikely then that the mosquitoes could not reach the often static water in the cisterns, while the osteological evidence from the collective tomb at Pyrgos suggests that the males buried there were in good health without much, if any, evidence for malaria (Cadogan, forthcoming a). It is, however, most probable that these individuals were part of the (healthier) elite of the settlement, and should not be taken as indicative of the health of all the inhabitants.

Alternatively, for reasons unknown, there could have been a shortage of persons to carry the water up the hill, although there were clearly enough people to build the two cisterns. Once they were built, however, and providing ample water facilities in the settlement, a lack of people to bring it up from below would not have been such a difficulty.

These two suggestions, however, do not address the fact that the cisterns were part of a remarkable MBA monumental building programme at Pyrgos, which also included the defence works and the presumed central building as well as continuing use of a collective tomb (that had begun in Pyrgos II). We see here a decision – unique in Minoan Crete at the time as well as later – to make a substantial water supply available in a hilltop settlement and provide (virtually) unlimited supplies of a vital commodity. It is an extraordinary reflection of the human resources and decision-making processes of this small settlement that so much could be achieved. This would have had a wide propaganda impact on other settlements in Crete (perhaps leading even to competitive, warlike reactions), while enabling the people of Pyrgos to enjoy the luxury of a self-sufficient abundance of water – a situation that is always something to covet in the Mediterranean.

In this context, one may ask whether there was a differentiation between the two cisterns. Could Cistern 1, set in a courtyard and certainly better, more evenly built, albeit smaller, than Cistern 2, have been used only for the central building on the top of the hill? And was Cistern 2 for everyone else? In view of the unique nature of this group of monuments, there is also the possibility that we should see Pyrgos as somehow primarily a ritual centre rather than simply a settlement (that also happened to have these specific, extremely important structures). If in a hard-to-define way an interpretation on these lines seems probable, then we could imagine ritual uses (also?) for the two cisterns. But what they would have been is equally hard to define.

One other, wider explanation would certainly have had local repercussions: namely, war and defence. Contra the widespread view of a pax Minoica in BA Crete, evidence is accumulating of war as an important part of the patterns of life, particularly in Protopalatial times, at an inter- and, quite possibly, intra-regional level (Alexiou, 1980; Nowicki, 1999). This seems to have culminated in destructions with fire at a number of settlements at much the same time as the destruction with fire of Pyrgos III – where the tower-bastion and walls were intended to prevent such disasters. In this scenario, the building of the two cisterns at Pyrgos can also partly, or perhaps wholly, be explained as
a response to a defence need – the threat of siege? – that did not exist to quite the same degree in other phases of the life of the Minoan settlement.

The cisterns' subsequent history

It is apparent during the subsequent Pyrgos IV phase that the social need of water storage on the top of the hill had passed and, we may assume, the inhabitants of Pyrgos now returned to collecting water from the river.

Cistern 2 and its surrounds became a rubbish dump for, principally, LM I (Pyrgos IV) pottery (some of which dates as late as the LM IB pottery in the destruction of the Country House). During this use the two higher-level walls already mentioned were built to form a small L-shaped structure, perhaps as a retaining wall for the rubbish. It is not clear whether this use as a tip should be seen as one of the ritual actions – ritual discarding – that were probably being performed in the settlement (and in particular by the occupants/users of the Country House); but it would be naïve to deny this as a possibility. Rubbish had already fallen down in – or after – the fire destruction that marks the end of the Pyrgos III phase, and would have come mainly, or wholly, from the central building on the top of the hill that was the precursor of the Country House. Perhaps there was ritual discarding to mark the end of that building and the establishment of the new one (the Country House).

Ritual is probably easier to discern with Cistern 1, which was entering a second life as an important part of the design of the Country House. This cistern was now filled to the brim with river pebbles – hard grey limestone sideropetres with white veining – and thus had lost any function for storing and supplying water. We may interpret this event as a ritual action, that could have taken place at one go – or over a period of time as people brought up pebbles from the river. If this is what happened, the intention was to mark the end of the one intact cistern as a cistern, and render it useless, by filling it with something that everybody would recognise as coming only from the traditional water source of the community – the river below. Yet the cistern was also highly visible to people approaching the Country House along the raised walk between the S front and the courtyard, or to those looking out over the courtyard either from a balcony which, I believe, was set above the verandah (stoà) on the ground floor of the building, or on coming out of the Country House through its main entrance.

It is important in this regard that Cistern 1 kept its round outline, and its plaster lining would have been visible, as it still was when we excavated 3,500 years later. It would have been clear to the people of Pyrgos IV that its previous use was as a cistern, even if now filled with pebbles that in themselves symbolised a return to the river, the customary source of water for Pyrgos. Following the “earth to earth, ashes to ashes, dust to dust” of the funeral service, can we may sum up the underlying attitude as “pebbles to pebbles”? Thus, these pebbles and the former cistern that held them could have kept the rich memory of the history of the community and the vicissitudes of its water supply – and so acted, or could be used, as an important tool for social cohesion. (The same applies to the long-lived collective tomb at the W corner of the settlement, which continued in use into Pyrgos IV; but, as far as we know, water is not involved there.)

If the two MBA cisterns of Pyrgos III were but a passing event in terms of functioning as cisterns, they did have their uses in their Pyrgos IV afterlife. The ruined Cistern 2 was for rubbish; the smaller Cistern 1 became an integral – and ideological – feature of the Country House and perhaps was the best reminder of the antiquity of the hilltop as a site for central buildings. But it may also have had a use as a soakaway for storm water from the Country House, the central building par excellence. Outside its W wall two clay drains were found, sloping down in the direction of the cistern. They are rectangular and
had lids – clay tiles – that could be removed for cleaning. The tops of the drain-ends were cut away so that one lid overlapped two drains. Painted on the lids and the drains (at the points where the lids were placed) are single, isolated motifs, of designs that are well known on the LM I pottery of Pyrgos and found notably on small jars used in the collective tomb. The drains are, almost certainly, local products. More than that, they too may have had a symbolic role – through their channelling water from the Country House to what had been the cistern of its predecessor – of uniting in a small way the two central buildings across time, while also alluding to particular iconographic motifs on the pottery that accompanied the dead in the last (Pyrgos IV) phase of use of the tomb – people who had most probably been the elite who used, and/or lived in, the Country House and would have seen Cistern 1 daily.

Early Minoan and middle Minoan comparanda

We should review briefly several other wide and/or deep round structures of Middle Minoan (MM) date on Crete that are associated with the Old Palaces of Knossos (4 structures) and Phaistos (4 or perhaps 5): see, recently, MacGillivray, 1994: 52; Halstead, 1997; Strasser, 1997; Carinci, 2001. They are broadly contemporary with the Myrtos-Pyrgos cisterns, and comparable in size. Sunk in the ground, they are known as kouloures (after a Greek word for something round and hollow). Malia has a set of eight round structures that project above ground, four at least being plastered, and are called silos (Pelon, 1980: 221–226). Their date, however, is problematic. The tendency now is to see them as LM I (Pelon et al., 1992: 178; Driessen and Macdonald, 1997: 185) rather than Protopalatial. At all three sites, however, these structures were set in, or immediately adjacent to, the West Courts of their palaces – apart from one kouloura at Knossos that is a short way away, below the later Theatral Area (Evans, 1935: 51, Fig. 30). They seem to have had design and symbolic connections with the ceremonial/ritual raised walks that are such a striking feature of these courts (Carinci, 2001).

It is generally agreed that the Malia structures were granaries. But how to interpret those at the other two sites is less certain, and seen by all as problematic. Alexiou (1964: 140–141) suggests they were depositories for sacred offerings; Strasser (1997) argues against their being granaries; Halstead (1997) restates the case that they were; Evans (1935: 61–66) suggested that (at Knossos) they were rubbish tips and/or “blind wells for the disposal of surface waters”, but not suitable as cisterns since they were not plastered; MacGillivray (1994: 52) inclines towards granaries, and points out that in any event the public may not have had ready access to them; Marinatos (1987: 135–138) also opts for granaries, to be associated with “harvest festivals” in the West Courts; following these and other leads, Carinci (2001) suggests that they were pits for planting trees, the trees having an important function in rituals enacted in the West Courts; but Watrous et al. (2004: 288) prefer their use (at Phaistos) as cisterns.

There was also at Knossos the so-called Hypogaeum by the South Front of the later Palace. Incompletely excavated, it is now re-buried and invisible – and also hard to interpret (Momigliano, 1991: 195–198; Wilson, 1994: 38; Belli, 1999). It is apparently a circular domed space cut in the soft natural rock, with a spiral stairway cut into its sides, some 8.32 m in diameter at the bottom and 15 m (or more) deep (Evans, 1921: 104–107, Fig. 74). Evans rejected the idea of its being a cistern, since the sides were not plastered, and thought that it might have been a guard house – or possibly a store pit. Hutchinson (1962: 163–164) was the first to suggest it was a granary. MacGillivray (1994: 54) opts for its having been a cistern. At least it is agreed that, as far as we know, it is of late Prepalatial date (whether EM III or MM IA).
These tantalising round buildings provide some help in interpreting the Myrtos-Pyrgos cisterns:
(a) They are all associated with central buildings (if on a far larger scale than that at Pyrgos), and were set in prominent positions in or by the West Courts, with raised walks beside them or leading towards them. Whatever their function(s), whatever they contained, in terms of prestige and display of power – the power of storing valuable commodities, whether foodstuffs or water – they are an important and often underrated feature of the communities that created them. The same holds for our Cistern 1. In its positioning and construction, it was clearly a competitive assertion of power, emulating the larger centres (But pending further study it is hard – but not totally impossible – to connect the apparently LM I raised walk outside the Country House with the overall original [Pyrgos III] design for this cistern.)
(b) It is clear that having plastered sides is a key factor for positive identification of a cistern, although it cannot exclude use as a granary.
(c) The ritual/ceremonial interpretation of the kouloures proposed by Carinci is a helpful lead in considering the role of Cistern 1, notably in its Pyrgos IV afterlife (when it could even have had a bush or flowers growing among the pebbles) but probably equally in its Pyrgos III original use.
(d) But Evans’s suggestion of a “blind well” for storm water is also helpful for Cistern 1, with the drainpipes leading towards it; while his idea of rubbish tips supports our explanation of Cistern 2.

Late Minoan cisterns
Of LM date are three plastered round structures, of diameter around 5 m, that held water and are usually called cisterns, although two of them may have had other uses besides just storing water. These two, of LM I date, are at Archanes-Tourkoyeitonia (Sakellarakis and Sakellarakis, 1992: 74, 112–115) and in the east wing of the Palace at Zakro (area LXII) (Platon, 1971: 185–191; 1992; Schofield, 1996). The third is of Postpalatial LM IIIA/IIIB date at Tylissos (Vasilakis, 1992). All three have a similar design – which is interesting evidence of the continuity of this plan – with steps leading down into the tank (unlike the Pyrgos cisterns), to give easy access to the water. They are also all plastered on the sides. The two earlier ones, however, do not have plastered bottoms, but are paved, to allow in each case the plentiful ground water to seep in between the stones and fill the cistern. It is not surprising, then, that Platon suggested that the Zakro cistern may have even been a private swimming pool (within the Palace), and the same could well hold for Archanes (where it seems to have been part of the palatial building at Tourkoyeitonia). The Archanes cistern also has an impressive drain to take the overflow. The later cistern at Tylissos is alone in having a plastered bottom: it seems a standard type of cistern collecting the water that was fed into it from above. But, finally, one cannot exclude the possibility that the two earlier LM cisterns also functioned at times as standard cisterns for water storage and distribution.

Conclusions
However we interpret the Knossos, Malia and Phaistos MM round structures, at Myrtos-Pyrgos at least one, and I believe both, of the two MM plastered round tanks functioned originally as cisterns. They are an important addition to the small corpus of Minoan cisterns, as the other certain examples are some centuries later, and to our understanding of how the Bronze Age Cretans managed their water supplies. In view of the presumed water availability during the BA in the Myrtos River below the settlement, it seems most probable that these cisterns were built to cope with unusual conditions, probably war,
while having an important social role for the community in making life less arduous by removing the need to go down the hill and up again to fetch a pail of water. We may also discern in these cisterns a symbolic and monumental role in the life of the community, and a competitive display/propaganda role in how it wished to express itself to other contemporary communities through building such rare and remarkable reservoirs among the impressive group of monuments of Pyrgos III. Parallels that come to mind, for the likely combination of the threat of war together with display and monumentality, are the large (rectangular) Hellenistic cisterns in the agora – the heart of the community – at Dreros and Lato, to which the Pyrgos cisterns offer a generic resemblance; and for the simultaneously social and symbolic importance (independently of any war factor) of managing water supplies as a way to ensure community cohesion and pride, we can recall the fountain house(s) of the 6th century BC Peisistratid rulers of Athens (Camp, 1992: 42–44) – or Francesco Morosini’s superb fountain of 1628 in Iraklio: Ta Liontaria. At present, the Myrtos-Pyrgos cisterns remain the earliest cisterns beyond dispute in Crete and are important evidence for social/political – and quite likely military – conditions on the island in the earlier part of the second millennium BC. That is what waterworks are, in all periods of human history.

Acknowledgements
I am very grateful to Dr. A. Angelakis for the invitation to present this paper, and Piraye Hacigüzeller, Eleni Hatzaki and Carl Knappett for help and advice.

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