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Voluminous Evidence for an Elusive Period: Storage Pits and Surplus from Middle Chalcolithic Anatolia

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ABSTRACT
Pit clusters have not received systematic attention from archaeologists working in Anatolia and the Near East, in contrast to many other parts of the world. This paper presents a case study of Middle Chalcolithic pits from the prehistoric site of Barcın Höyük in northwestern Anatolia to show how pit clusters, interpreted as underground grain silos, can inform us about ancient food economies, social organization, and inhabited landscapes. It is argued that the silos at Barcın Höyük were used by small family-sized groups to store surplus grain. Dated to the first quarter of the 5th millennium B.C., the silos present evidence for agricultural productivity during a period that has largely eluded archaeological investigation in western Anatolia.

KEYWORDS
grain silos; underground storage; agricultural economy; prehistory; Barcın Höyük; Turkey

Introduction

No matter how well investigated the archaeology of a region, there is never a full balance in our knowledge across time. Some periods will have produced a wealth of sites, monuments, and artifacts, giving us the idea that we have a good understanding of the time. Other periods will have left fewer or less impressive remains, be correspondingly less well-known, and more often than not will also receive less attention from archaeologists. Poorly known periods challenge us to find alternative ways to increase our knowledge about them, collecting and exploiting information from hitherto ignored sources to study the lifeways of the time. This paper proposes that pit clusters have the potential to inform us about one such poorly known period, the Anatolian Middle Chalcolithic.

The Middle Chalcolithic in western Anatolia

In Anatolian archaeology, the Chalcolithic (ca. 6000–3000 B.C.) still counts as one of the lesser known periods (Düring 2011; Schoop 2005), wedged chronologically between the Neolithic and the Bronze Age and thematically between the origins of sedentary farming and the beginnings of state formation and urbanization. The Middle Chalcolithic (ca. 5500–4000 B.C.) is a period where scarce archaeological remains and limited sustained archaeological interest go hand in hand. In much of central and western Anatolia, when the preceding Early Chalcolithic (culturally a direct continuation of the Neolithic) ends around 5600/5500 B.C., the remainder of the 6th millennium B.C. is described in terms of site abandonment and disruption, followed by the appearance of new types of settlements and habitation practices (Baird 2005; Çevik and Erdoğu 2019, 2020; Düring 2011; Marciniak and Czerniak 2007; Thissen 2002; Van den Bos 2021, 344–351; Vandam 2015). From the following millennium or so, few sites are known from dispersed and varied landscapes within the western Anatolian realm, and even fewer are well investigated and dated (Figure 1).

A decade ago, the known Middle Chalcolithic sites were reviewed by Bleda Düring (2011), and the dataset has not significantly increased since then (but see updated information on the Troad [Blum 2014] and Phrygia [Türkcan 2017]). Düring distinguishes between two settlement types: ephemeral settlements, sometimes located away from agriculturally productive areas, that may represent short-lived or seasonal occupation, and more substantial settlements with evidence for architectural differentiation. To date, settlements of the latter type are only known from Cappadocia in central Anatolia and include the important site of Güvercinkayası. Dating to the early 5th millennium B.C., this site consists of stone-built architectural complexes divided over a fortified citadel and a lower sector (Gülçur 2012). Each complex has its own storerooms of varying capacity (Çaylı, Demirtaş, and Gülçur 2020). The site of Canhasan I (Layer 1), to the southwest of Güvercinkayası and dated to the late 6th millennium B.C. (Thissen 2002), equally appears to have been of considerable size, but is characterized by make-shift, constantly modified architecture (French 1998).

In inner western Anatolia, the Middle Chalcolithic period has been investigated at Orman Fidanlığı near Eskişehir (Efe 2001). The salvage excavations documented a multi-phase stratigraphy on a steep, rocky hillside, indicating sustained habitation. But few intact architectural remains were found, and the nature and spatial organization of the settlement remains unclear. The ongoing excavations at Kanlıtaş, not far from Orman Fidanlığı and also situated against a rock outcrop, will potentially provide much-needed clarification of what settlements looked like in this period in the region (Türkcan 2017).

Other sites described by Düring generally appear to have been short-lived, ephemeral settlements, perhaps reflective of an increased dependence on a (partly) mobile lifestyle

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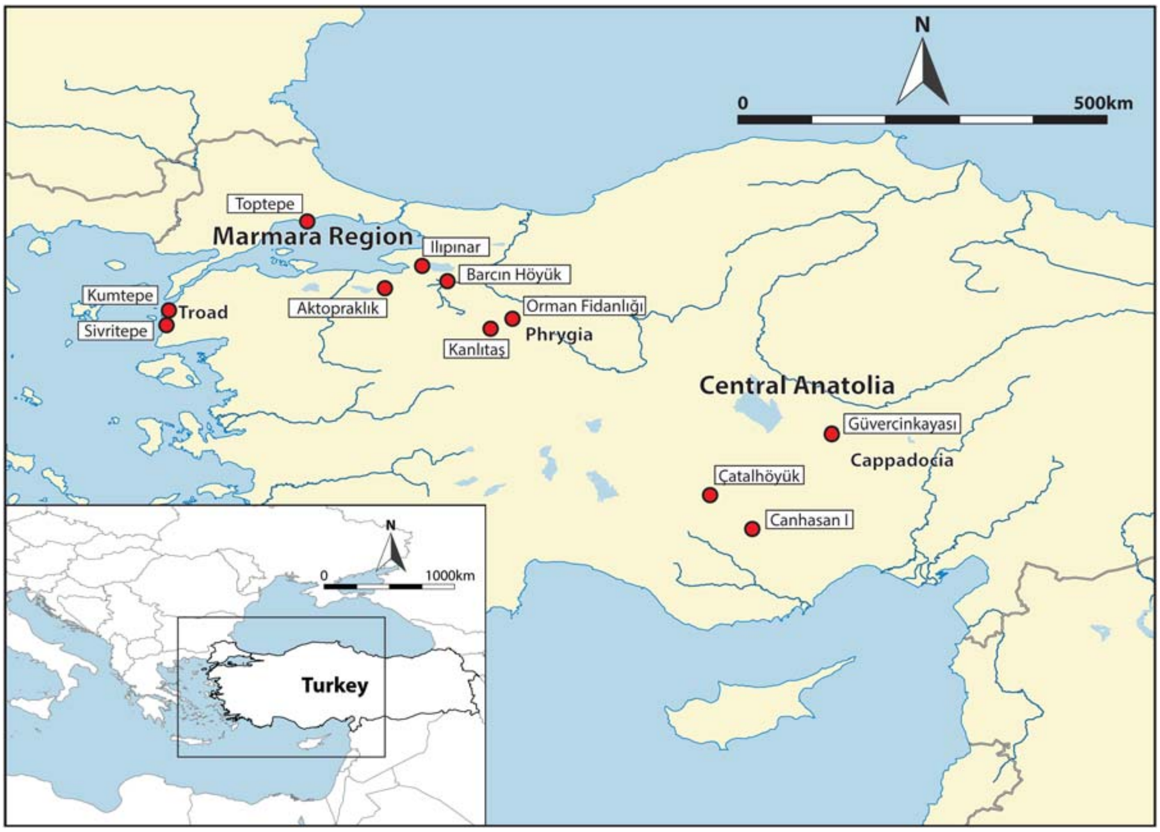

Figure 1. Map of central and western Turkey with sites and regions mentioned in the text.

(Düring 2011). This category includes two sites in the southern Marmara Region, Aktopraklık B "late" (Karul 2017, 111–114) and Ilıpınar VB (Roodenberg and Alpaslan Roodenberg 2013, 73, fig. 8). Dating to the transition from the Early to the Middle Chalcolithic, both sites showed clusters of semi-subterranean dwellings sunken into Early Chalcolithic settlement mounds. Several other sites are worth mentioning here because of the apparent importance in their food economy of marine resources, including Toptepe (Özdoğan 2013) and Kumtepe and Beşik-Sivritepe in the Troad (Boessneck 1986; Düring 2011).

The occurrence of Middle Chalcolithic sites in different part of western Anatolia shows that the region was inhabited, but beyond this observation, the datasets preclude a further characterization of the communities, their settlements, and their food economies. It is clear that any newly emerging data can significantly add to the empirical basis for the period.

The archaeology of pit clusters

This paper aims to show how we can better understand poorly known periods like the Middle Chalcolithic by looking at a category of previously ignored archaeological remains as a source of relevant information: pit clusters. Pit clusters are a common phenomenon in archaeological sites in prehistoric, Roman, and medieval Europe (e.g. Bossard 2019; Deffressigne 2012; Prats, Antolín, and Alonso 2020a, 2020b) and are also known from North and South America (e.g. DeBoer 1988; Laguens 1993) and from Africa (e.g. Gronenborn 1997). Clusters range from a handful of pits on a farmyard to extensive fields of many hundreds of pits located away from a settlement. There is a widely shared notion that they represent clusters of underground storage silos (cf. Jiménez-Jáimez and Suárez-Padilla [2019] for a recent discussion of debates on silo storage in archaeology and ethnohistory). An anaerobic environment will quickly develop in a pit filled with cleaned, loose grain and sealed hermetically to prevent air and moisture from entering. This environment is hostile to insects, fungi, and other microbes and prevents the grain from spoiling (Hill, Lacey, and Reynolds 1983; Reynolds 1974; Sigaut 1980, 1988). As long as the seal remains intact, large quantities of grain can be kept for a year or more, making this system especially suitable for long-term storage of reserves, though less so for daily consumption. Clusters of underground silos reflect the scale of storage and the duration of use of the site.

In the ethnographic literature, there is broad consensus that underground silos served specifically for storing cereals, including wheat, barley, sorghum, and millet (Jiménez-Jáimez and Suárez-Padilla 2019; Sigaut 1988). Rice and maize are also reported (Caliboso and Sabio 1998; DeBoer 1988), as are nuts (Cunningham 2005; Sanger 2017), but these are less relevant for the current case study. Beyond cereals, a recent cross-cultural study has not found any ethnographic cases of the use of underground silos for the storage of pulses and indicates that lentils, chickpeas, and peas were instead commonly stored in bins, ceramic vessels, and containers made from perishable materials (Tarongi, Prats, and Alonso 2020).

In the literature on Anatolian and Near Eastern archaeology, underground silos feature less frequently (but see Currid and Navon 1989; Perrot 1955), but it is hard to say whether this lack is because the practice was uncommon or because archaeologists have not paid sufficient attention to the phenomenon of pits and pit clusters. With few exceptions, such as burials, the primary function of pits in archaeological excavations is notoriously difficult to infer. Particularly in stratified sites, pits tend to be studied more because of the destruction of older levels they cause than for their original functions, let alone for how they may enlighten us about the groups that dug and used them. For a poorly-known period like the Middle Chalcolithic, we argue that not only do we not have the luxury to ignore classes of data like pit clusters in pursuit of more data-rich contexts, but we must also consider that it may be precisely the presence of such features that can tell us something fundamental about life in this period.

This paper presents a case study of a Middle Chalcolithic cluster of pits dug into the Neolithic mound of Barcın Höyük in northwestern Anatolia (Figures 1, 2). The predominance of pits in this period (Barcın Höyük level Vb) has urged a move beyond the default "refuse pit" label. Here, I investigate the hypothesis that many of the pits at the site were silos for underground bulk grain storage and explore the implications of this interpretation for understanding the Middle Chalcolithic community that used them. In this, I take a different approach to pits than is being proposed for the 6th millennium B.C. Aegean site of Uğurlu, where pits are paralleled to house destruction and renovation rituals (Karamurat, Atakuman, and Erdoğu 2021).

Barcın Höyük

Barcın Höyük is located in the Yenişehir Valley to the east of the modern city of Bursa (see Figure 2). The site consists of two small mounds separated by a saddle, together covering an area of 2 ha. Excavations on the eastern, higher, mound took place in 2005 and 2006 under the direction of Jacob Roodenberg (Roodenberg, van As, and Alpaslan Roodenberg 2008) and between 2007 and 2015 under the direction of Fokke Gerritsen and Rana Özbal. The main research focus of the excavation project concerned the 7th millennium B.C. Neolithic habitation (level VI) (Gerritsen and Özbal 2016, 2019; Gerritsen, Özbal, and Thissen 2013; Özbal and Gerritsen 2019), but also investigated later periods of activity. Neolithic occupation at Barcın Höyük ended around 6000 B.C. or slightly later. After the mound was left uninhabited for about a millennium, it was re-occupied for what appears to have been a short period during the Middle Chalcolithic (level Vb). This habitation is then followed by another hiatus that lasted until the early 4th millennium B.C., when the mound was occupied during the Late Chalcolithic Period, level Va (Gerritsen et al. 2010; Özbal et al. 2017). Later episodes of activity at the site date from Early Bronze Age II (level IV), the Early–Middle Bronze Age transition (level III), and the Byzantine Period (level I) (Gerritsen and Özbal 2009; Roodenberg 2009). Surface finds indicate

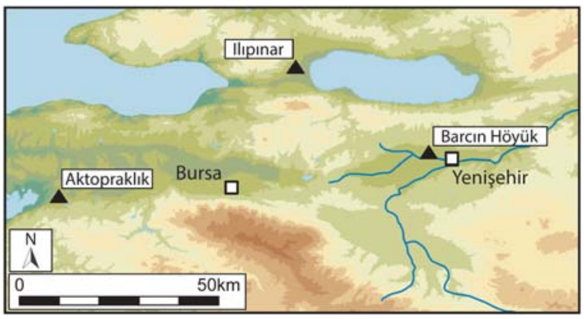

Figure 2. Relief map of the Bursa region with archaeological sites (black triangles) and modern towns (white squares).

activity also during the Classical era (level II), but no in situ remains were found.

There is no direct evidence from plant remains to determine which crops were cultivated at Middle Chalcolithic Barcın Höyük. Most likely, most or all of the crops that had become staples of the Neolithic and the later Anatolian and Near Eastern food economy (wheat and barley in several variants, lentils, chickpeas, and peas) were grown at Barcın Höyük. This broad spectrum has been observed in the Neolithic levels at the site (Balcı et al. 2019), as well as in Early Chalcolithic and Middle Chalcolithic levels at nearby Ilıpınar (Cappers 2008).

Description of Features

Discovery, documentation, and identification

Level Vb occupation has been encountered in nearly all excavated trenches: near the top of the mound, on the flanks, and at the southern foot of the mound (Figure 3). The large majority of Vb features consists of pits. At the foot of the mound, several deposits and a pyrotechnic installation represent the sole Vb features that are not pits. It should be clarified at the outset that the Vb remains were not recognized as representing a separate phase of occupation until the final seasons of the excavation campaign, through analysis of the ceramic assemblages rather than through field observations. As a result, the analysis of this phase is based on a dataset that contains more than the normal degree of ambiguity and uncertainty.

Several factors contributed to the delayed recognition of a Middle Chalcolithic occupation phase. First, due to the nature of Vb activity—digging rather than building—there was no significant build-up of deposits on the top and flanks of the mound. Second, during the period of abandonment of some 1000 years between levels Vb (Middle Chalcolithic) and Va (Late Chalcolithic), soil formation took place on the mound surface that transformed the matrix of the top 0.5 m or so. This led to the disappearance of variations in color and texture between the Vb pit fills and the Neolithic deposits that they were dug into. We can reconstruct that most Vb pits were first recognized as pit cuts some 50–80 cm below the surface from which they were dug. Third, the uppermost Neolithic level, level VIa, consists mainly of homogeneous deposits heavily dug through by rodent burrowing and included very few intact features against which Vb pit cuts and fills could be recognized. Moreover, Vb pits were found spatially intermingled with VIa pits, both reaching into the Neolithic layer VIb below. Finally, the fills of all Vb pits contain artifact assemblages that include significant amounts of Neolithic ceramics, probably having been dug up from the levels that the pits were cut into.

Foot and slope of mound

In the southernmost extent of the excavated area at the foot of the mound, a deposit of some 30 cm in depth could be traced over an area of 4.75 × 4 m (see Figure 3). It has been assigned to level Vb on the basis of the associated ceramic assemblages. Here, the base of a rounded hearth or oven with a diameter of some 90 cm was also found. The surface associated with this hearth was not detected. The presence of the hearth and the build-up of a deposit around it

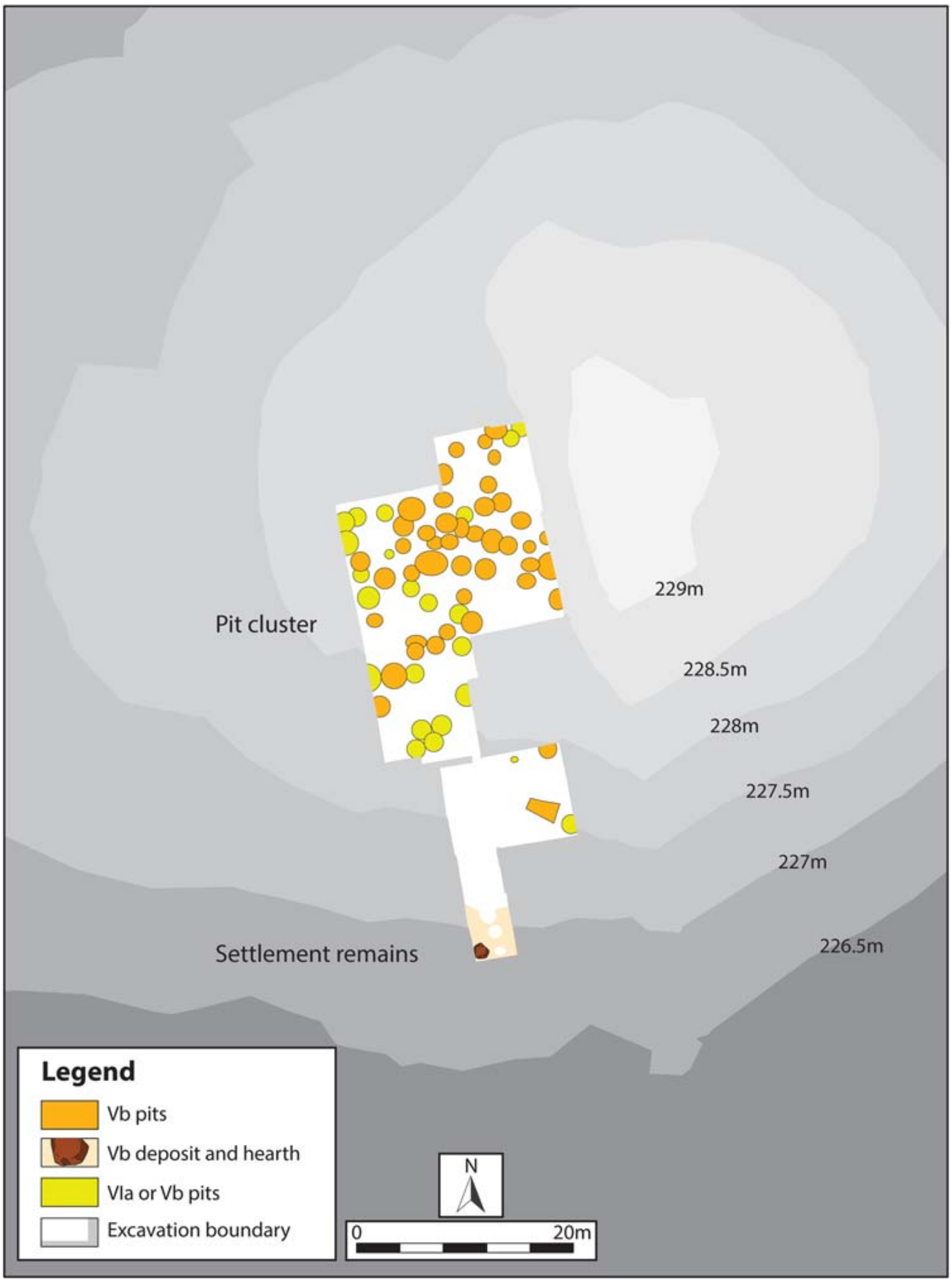

Figure 3. Elevation plan of the eastern mound of Barcın Höyük showing the excavated area and generalized distribution of Vb and possible Vb pits.

suggests that Middle Chalcolithic habitation was situated at or beyond the foot of the Neolithic mound. Along the slope of the mound, the excavations yielded only a few traces that could be assigned to level Vb on the basis of the associated ceramics. This includes a trapezoidal pit of unknown function with a maximum longest extent of 2.7 m.

Top of mound

The upper slopes and the top of the mound show a large cluster of pits (Figure 4). The excavated area of pits covers some 350 m^2, but the cluster probably extended further to the north, east, and west. Some 60 excavation contexts can be dated with a high degree of confidence to level Vb. In a number of instances, small groups of intersecting pits were excavated as single contexts, while in other instances, single pits were excavated under more than one context identifier. The 60 excavation contexts are estimated to represent at least 41 individual features. In addition to Vb pits, there are also some 30 pits that date from the same level or from the final level of Neolithic occupation, level VIa. This uncertain category includes pits of which the ceramic analysis was inconclusive or has not yet been done.

The documentation of the fills of the Vb pits is uneven in detail, but several pits that were sectioned because of their location at trench edges show layered, mixed fills (Figure 5). Heaped dirt piles on pit bottoms produced conical patterns. This indicates that pits filled up quickly, possibly because they were deliberately refilled. Pit fills typically yielded assemblages of ceramics, chipped stone, and animal bone, with occasional bone tools and clay animal figurines. Based on the ceramics, in most cases assemblages dominated by Neolithic sherds with an admixture of Middle Chalcolithic ceramics, it can be concluded that the artifact assemblages from the pits are a mixture of Neolithic and Middle Chalcolithic materials and can tell us little about the pits' uses or about the Middle Chalcolithic community that used them. Regrettably, there are no botanical samples that

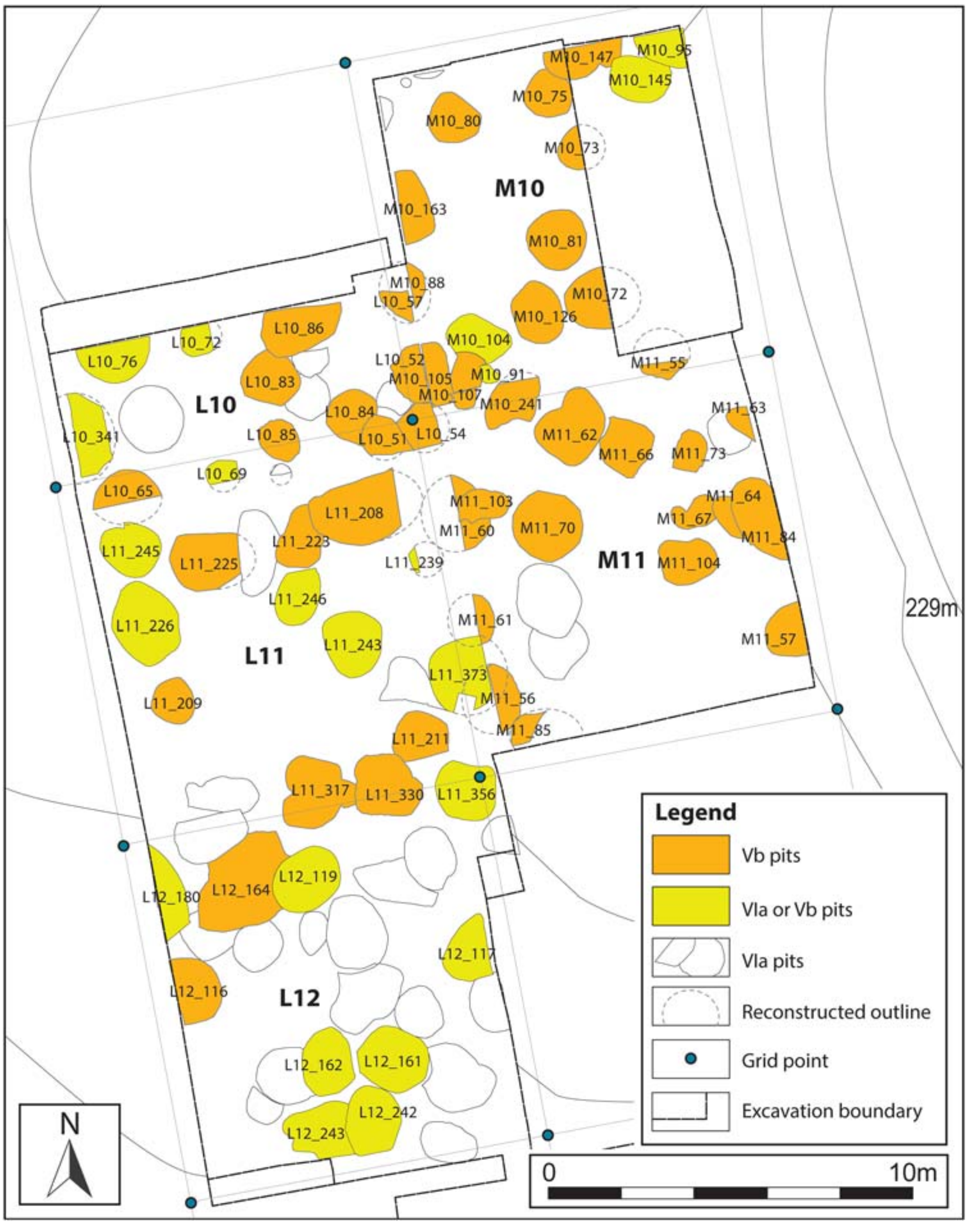

Figure 4. Barcın Höyük. Overview of pit cluster on the upper slopes and top of the mound.

can be confidently assumed to represent uncontaminated Middle Chalcolithic plant remains.

Nature and date of the Vb occupation

Based on the excavated section of the mound, it is difficult to know how representative the documented features are for the use of the site as a whole. An unanswered question is whether there were domestic structures outside the excavated section. Some evidence points to settlement remains at the foot of the mound, but the high groundwater table in the prehistoric Yenişehir Valley (Groenhuijzen et al. 2015) argues against the suggestion of an extensive settlement on the valley bottom floor. What does seem clear, however, is that the excavated section of the top of the mound was largely reserved for a usage that involved deep and large pits. Intersecting pits show that they were dug and used at different times. This observation warns us not to see the plan as representing a single moment in time, but rather as the end result of multiple overlapping episodes of pits being dug, used, and refilled.

Three AMS dates on charcoal from Vb pits cluster tightly between 5981–5955 uncalibrated B.P. (Table 1). Another AMS date that was obtained from a context that stratigraphically could belong to level VIa or to Vb is very close to this date range. In absolute years, the AMS dates point to a period of occupation during the first quarter of the 5th millennium B.C., and more specifically to around 4900–4800 CAL B.C.

Interpreting the Pits as Silos

To explore the hypothesis that the Middle Chalcolithic pits of Barcın Höyük are silos, we need to investigate them more closely. Many of the 41 pits and pit complexes that have been confidently dated to level Vb are roughly circular in plan (see Figure 4). Some have been drawn with more irregular outlines because of difficulties with observing and documenting the original pit outlines or because the cuts of multiple intersecting pits were excavated as a single unit. As pits were excavated, often in step with the surrounding deposits, the outline of their cut was also drawn on multiple plans. Comparing sequences of plans, it is clear that while

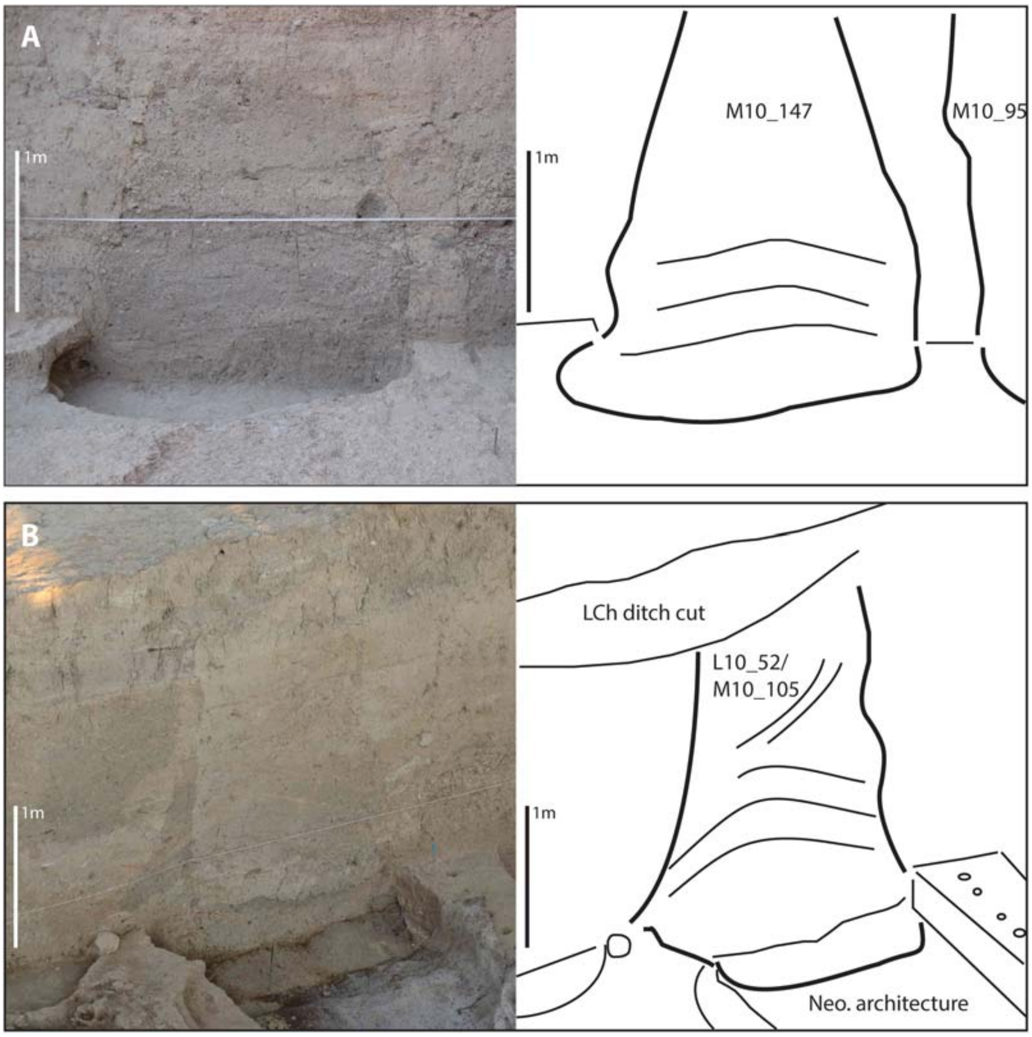

Figure 5. Barcın Höyük. Profile photos and schematic sections of bell-shaped pits A) M10_147 and B) L10_52/M10_105.

Table 1. AMS dates for Barcın Höyük level Vb.

Sample Number	Material	Context	Lab Code	Uncalibrated B.P.	CAL B.C. (95%)*
BH47951	Wood charcoal	Vb pit L10_86	Tübitak-1464	5981 ± 32	4987–4968, 4955–4784
BH47952	Wood charcoal	Vb pit L10_84	Tübitak-1465	5955 ± 32	4936–4770, 4761–4726
BH47955	Wood charcoal	Vb pit M10_71 (equals M10_126)	Tübitak-1468	5976 ± 29	4948–4783, 4742–4736
BH47963	Wood charcoal	VIa pit M13_52	Tübitak-1476	6020 ± 31	5000–4834, 4813–4801

*Calibrated with OxCal 4.4 (calibration curve IntCal20 Northern Hemisphere; Reimer et al. 2020).

some pits have vertical sides, the diameter of many others increased from top to bottom.

Slanting pit sides and bell-shaped pit profiles have also been observed in cases where trench sides intersected pits. Figure 5 shows two pits in profile, both examples of bell-shaped pits with heaped fills. Bell-shaped or beehive-shaped pits are connected in the experimental-archaeological and ethnographic literature with grain storage because the narrow opening makes it relatively easy to create an impermeable mud seal in the mouth of the pit, and this shape has a favorable volume to external surface ratio, limiting the amount of grain that sits in direct contact with the sides of the silo (see Prats, Antolín, and Alonso 2020a for a silo typology).

Depth and diameter calculations

As was discussed above, Middle Chalcolithic activity on the higher parts of the mound did not lead to significant mound build-up. Pit digging would have taken place from a surface (the top of the Neolithic mound from a millennium before) that remained more or less stable over the course of the Middle Chalcolithic period of activity. For the central group of trenches (L10, M10, L11, and M11), the elevation of this surface can be equaled to 227.3 masl, and this is assumed to be the approximate elevation from which all pits in this area were dug. On the flanks of the mound, where trench M13 and (the southern part of) L12 are located, this level is estimated to have been at ca. 226.9 masl.

Figure 6A shows the calculated pit depths for 41 Vb pits/pit complexes, based on the reconstructed top elevations of 227.3 and 226.9 masl. Where the ceramic analysis indicates that a pit was excavated to below its basal boundary, the lowest level at which Middle Chalcolithic ceramics were encountered was used. The average pit depth is 1.88 m, with 68% of the pits reaching depths between 1.5 and 2.5 m.

Although the mouth of none of the Vb pits was observed, we can use the basal (which is often also the maximum

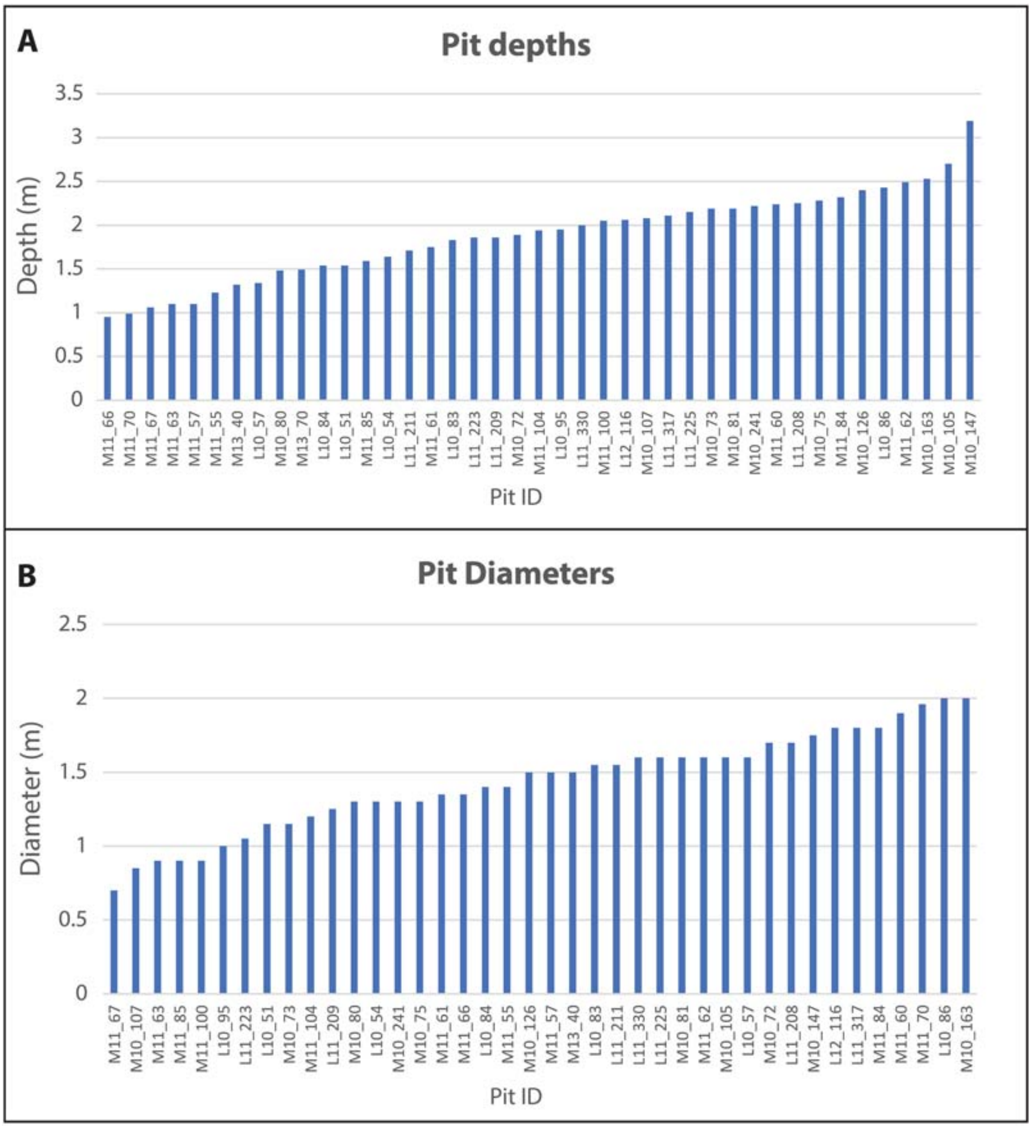

Figure 6. A) Reconstructed pit depths of Vb pits; B) diameters of Vb pits.

recorded) diameter to gain a further sense of the size of these pits. Figure 6B shows the maximum recorded diameter of 40 pits/pit complexes (excluding the trapezoidal pit in trench M13 on the southern flank). The average basal diameter of pits is 1.43 m, and 83% of pits have diameters between 1 and 2 m.

The depth to diameter ratio can help identify pits that are not likely to have been used as underground silos. Pits that are very wide and shallow (i.e. a low depth:diameter ratio) are less suitable for storage, because their openings are difficult to seal. Pits that are very narrow have an unfavorable surface to volume ratio, leading to a higher proportion of spoilage (DeBoer 1988, 5; Jiménez-Jáimez and Suárez-Padilla 2019). In experiments conducted in the 1970s at Butser Farm (UK), Peter Reynolds successfully stored grain in pits with a depth of 1.5 m and a diameter of 1.25 m (a ratio of 1.2) and with 1 m depth and 0.66 m diameter (a ratio of 1.5) (Hill, Lacey, and Reynolds 1983; Reynolds 1974). Ethnographic observations among mid-20th century Bedouin in Israel show that pits were between 1 and 3 m deep, with a basal diameter of 1–1.5 m, that is, ratios ranging from 1–2 (Currid and Navon 1989).

Figure 7A shows that the depth:diameter ratios of 32 out of 41 pits fall between 1 and 2 (78%). The average ratio among those 32 is 1.42. Seven pits have ratios below 1 and are less likely to have been used as silos. There are two pits with ratios above 2: M11_100, which is unusually narrow, and M10_107, a pit that was cut by M10_105 and may originally have had a larger diameter.

The characteristics of the pits as described here indicate that most, if not all, of the pits on the upper part of the mound were constructed in such a way that they were suitable to function as silos for bulk grain storage. In particular, the bell-shaped profile that could be observed in some pits and inferred in others seems to preclude other functions. In the absence of convincing alternative functions for the pits, we therefore assume that the upper part of the mound was an area specifically reserved for underground storage facilities.

Silo volumes

To gain an insight into the scale of storage facilities at the site, however limited by uncertainties of documentation and interpretation, it is possible to estimate the volume of pits. Above, pit depths were reconstructed for 32 Vb pits/pit complexes that have been identified as possible silos on the basis of their depth:diameter ratio. Even though probably not all pits originally had a bell-shaped profile, it is

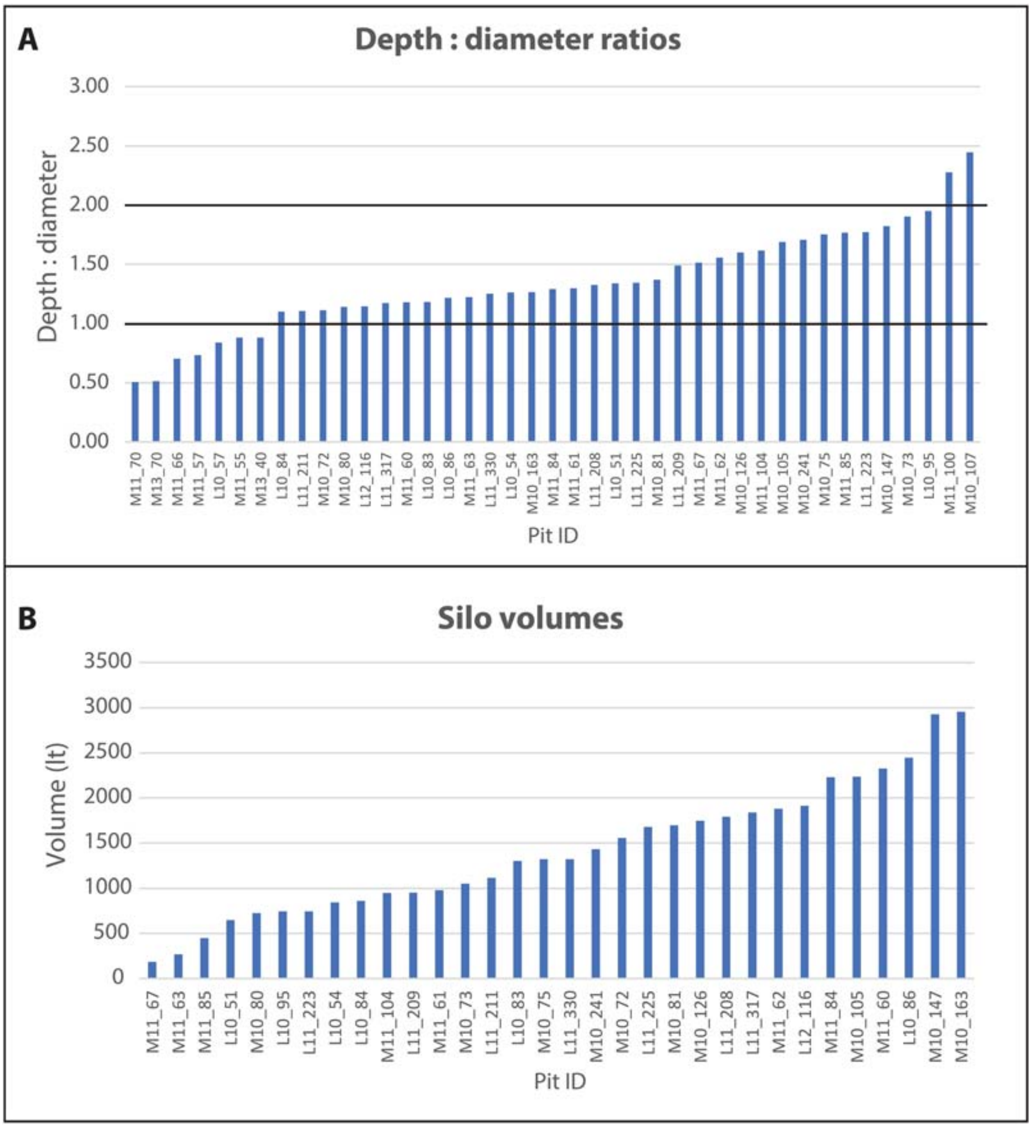

Figure 7. A) Depth:diameter ratios of Vb pits; B) calculated volumes of Vb silos.

impossible to determine the three-dimensional shape for each individual pit. Not to unduly overestimate storage capacity, we assume that each pit can be approximated as a truncated cone with a narrower diameter at the top than at the base (Figure 8). We also assume that the top 50 cm were used for a mud capping. Using the basal diameter as recorded, the original height as reconstructed (minus 50 cm), and an estimated standard 60 cm diameter of the neck, the volume of each pit can be calculated (formula from Pamuła n.d.). Figure 7B shows the calculated volumes of the 32 silos. Pit volumes range between 186 and 2955 L, with an average of 1409 L per pit. Removing the two smallest and two largest volumes from the calculation decreases the average volume slightly, to 1384 L.

These calculations do not take into account that pits were affected by post-use modifications, such as caving in (DeBoer 1988), and potential overcutting in the excavations. As Figure 8 shows, the way the volumes are calculated as truncated cones underestimates rather than overestimates the volume of a bell-shaped pit as excavated and thus corrects for post-use increases in diameter due to erosion and overcutting. While the calculations provide informative indications about the sizes present in the group as a whole and about the range of the sizes of the silos, it should be stressed that these figures can only be taken as rough approximations.

Discussion

The observations and inferences made so far can be summed up as follows: the formal characteristics of the Middle Chalcolithic pits on the top of the mound support their interpretation as a cluster of silos for underground storage. Given the ethnographic evidence and consensus in the relevant literature that underground storage in such silos was used historically (almost) exclusively for cereal grains, we can interpret the pits more specifically as grain storage pits, even though there are no archaeobotanical data to support this conclusion, let alone to specify the types of cereals stored. Intersecting pits indicate that not all silos were in use at the same time. Silos demonstrate a considerable range of volumes around an average of ca. 1400 L.

At this point, two topics present themselves for further discussion. The first concerns the scale of the storage, as a way to gain insight into the size of the group or groups that were using the silos. The second, related, topic concerns the social organization of grain storage. By exploring these topics for Middle Chalcolithic Barcın Höyük, we add to

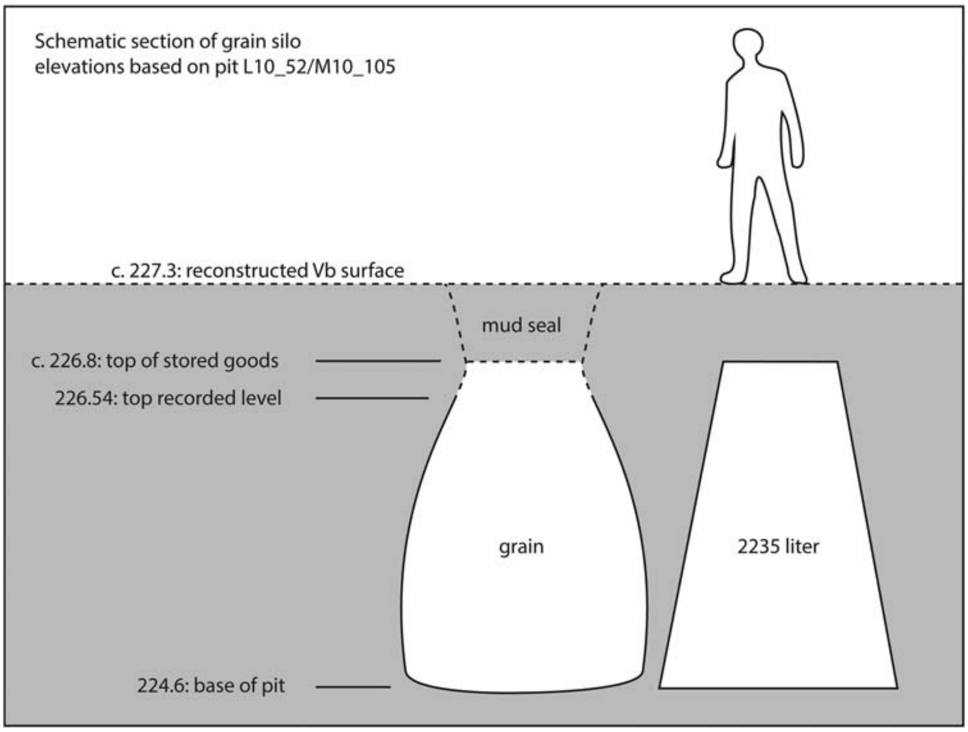

Figure 8. Schematic pit profile with volume calculation as truncated cone; not to scale.

several studies that have been conducted in recent years on storage practices in early agricultural societies in Anatolia (Bogaard et al. 2009; Cappers 2008; Çaylı, Demirtaş, and Gülçur 2020; Roodenberg 2012) and contribute to a growing topic of research in archaeology more generally (Jiménez-Jáimez and Suárez-Padilla 2019; Prats, Antolín, and Alonso 2020a, 2020b; Rocek 2020), as well as in contemporary agronomic studies that investigate how traditional, low-cost storage strategies can help ensure food security under changing climatic conditions (Abdalla et al. 2002; Mobolade et al. 2019).

The scale of storage

Underground storage differs from storage in bins, ceramic vessels, or containers of perishable materials inside dwellings in several aspects. These differences need to be kept in mind when delving deeper into storage practices. For underground storage to work best, an anaerobic environment needs to be created and maintained. This is done by ensuring that a silo is completely filled when first sealed in order to minimize the available oxygen for microbes to live on (remaining oxygen is then used up as a small amount of the grain spoils). In other words, the volume of an underground silo represents the amount of actual stored grain, rather than an owner's estimate of potentially needed volume, as in the case of aboveground granaries, storage rooms, or bins. The technique also implies that silos tend to be used for stores that are not needed immediately. Previously used silos need to be thoroughly cleaned to remove remaining insects, fungi, and other microbes, usually by burning a fire inside them. Conceivably, regularly replacing silo pits by newly dug ones was an easy method to further lower the risk of contamination (Jiménez-Jáimez and Suárez-Padilla 2019). This means that, in contrast to bins, ceramic vessels, and built depot spaces, a silo represents an actual storage event (or short sequence of events), rather than storage potential.

The total calculated volume of the 32 silos identified at Barcın Höyük comes to about 45,000 L (or 75,000 if the "VIa or Vb" pits are included), but these totals as a measure of storage capacity are of limited significance. We already know archaeologically that not all silos were in use at the same time, and the above-mentioned general characteristics of underground storage practices further underline that at any particular point in time, only part of the silos were in use, and potentially only very few. As we don't know the duration of Middle Chalcolithic activity at the site, it is impossible to estimate how many pits on average were in use concurrently. The volumes of the individual silos can provide more insights, however. How does the average of ca. 1400 L compare to volumes established in other cases? And what explanations can there be for the variation in volumes?

Some comparative figures can provide insightful contexts. The authors of a recent study of more than 1600 silo pits dating from the Early Neolithic–Late Iron Age from 172 sites in northeastern Spain demonstrate a chronological increase in storage capacity by calculating the range of volumes in the central 50% of pit volumes (Prats, Antolín, and Alonso 2020b). They find that 50% of pits in the Early Neolithic range between 319 and 677 L. By the Early Bronze Age, this has increased to between 540 and 1362 L, and by the Late Bronze Age to between 1320 and 2719 L. The authors argue that the figures, when combined with data on settlements, agricultural systems, and technology, show that, whereas surplus production was uncommon in the Neolithic, Bronze Age domestic units were customarily producing and storing surpluses (Prats, Antolín, and Alonso 2020b, 21). Indications for supra-household production, in the form of extraordinarily large silos (outliers well above the range for a given period) also become more common in the Bronze Age in comparison to the Neolithic phases.

At Barcın Höyük, this same middle 50% has volumes between 866 and 1838 L, and there are two outliers at 2927 and 2955 L. According to the Iberian classification scheme, the site would be described as more Bronze Age-like than Neolithic-like, with indications for regular surplus production and potentially also for occasional supra-household production. The important observation by Prats, Antolín, and Alonso, however, that such volumes can only be interpreted in terms of domestic, surplus, or supra-household production in conjunction within contemporary data on settlements and agricultural technologies (2020b) also applies to the Barcın Höyük dataset. We should be careful not to transpose Iberian classifications one-to-one to Anatolia.

Ethnographic observations from Greece also provide figures for comparison. Halstead reports that traditional farmers practicing non-mechanized farming felt that 1–1.5 tons of grain were needed annually by a family for consumption and a buffer for losses. Depending on whether naked or hulled grains are stored, this requires between 1300 and 3000 L of underground storage capacity (Halstead 2014, 162). The range of silo volumes of Barcın Höyük fits very well with the Greek figures, suggesting that they could also represent the production of individual domestic units. The main differences in social and technological contexts in which Middle Chalcolithic and 20th century Greek farmers operated should not be overlooked, however. The latter had access to plows and oxen, significantly increasing productive capacity, and had the option to sell excess surplus at the market (Halstead 2014). Both would presumably not have existed in Middle Chalcolithic Anatolia.

Context to the Barcın Höyük case study is further provided by several Anatolian studies on prehistoric grain storage. At nearby Ilıpınar VB, ceramic vessels, bins, and sacks were used for storage of cereals and pulses (Cappers 2008; Roodenberg 2012). For one of the excavated huts, a total storage volume of 50 L was reconstructed and, for another, 130 L. On the basis of the absence of weed seeds in the botanical samples retrieved from the vessels, archaeobotanist René Cappers proposed that these were stocks of sowing seeds (Cappers 2008, 131). Storage facilities (bins and floor space for perishable containers) inside houses at 7th millennium B.C. Çatalhöyük were calculated to hold on average ca. 1200 L per house, ranging between about 200 to well over 2000 L (Bogaard et al. 2009). Such amounts are considered too large for dedicated sowing seed storage (intensive manual cultivation requiring limited quantities of seeds; cf. Sigaut 1988) but commensurate with the annual requirements of a small family of 5–7 people (Bogaard et al. 2009, 661–664; Halstead 2014).

To this can be added the insights from studies carried out at the Middle Chalcolithic site of Güvercinkayası in central Anatolia (Çaylı, Demirtaş, and Gülçur 2020). This site belongs to a small group of fairly substantial settlements in central Anatolia dating to the early 5th millennium B.C. (Gülçur 2012). The storage capacity of a number of individual houses was calculated on the basis of their depot spaces, bins, and storage vessels. In most houses, the calculated capacity ranges between 220 and 1500 kg, but the largest and most substantially-built house complex had a total capacity of 7600 kg. This intra-site variation is interpreted as an indication of surplus production and a redistributive system under the control of the inhabitants of the largest complex (Çaylı, Demirtaş, and Gülçur 2020), as well as of the presence of a staple-finance economy (Özbal 2020). Also dating to around 5000 B.C., Tell Tsaf in the southern Levant yielded tower-like silos with capacities between 4 and 25 tons of grain. Set in groups within the courtyards of residential complexes, they are taken as indications for early social and economic complexity (Garfinkel, Ben-Shlomo, and Kuperman 2009).

From these comparisons, several relevant insights can be drawn. On the whole, the Barcın pits are too large for storing sowing stock and thus would have served primarily as grain stores set aside for future consumption. The similar average volumes at Çatalhöyük and Barcın, 1200 vs. 1400 L, respectively, suggest that the silos at Barcın also represent the stocks of small groups like households or families of 5–7 people.

Beyond the averages, what to make, then, of the variation in volumes? Even if we assume that some of the smallest pits interpreted as possible silos were not actually used as a such, at almost 3000 L, the largest silo is still some five or six times larger than the smallest ones. Could this be a reflection of the co-existence at Barcın of domestic, surplus, and supra-household forms of production, as suggested by the analogy with the Iberian study above?

To answer this question, we need to qualify what is meant by surplus here. Jiménez-Jáimez and Suárez-Padilla (2019) point out that when storage in underground silos is practiced, it often serves to put aside surplus from good harvests to cover bad harvests in another year. Following this line of thinking, it would appear that the size of the silo was based on the volume of grain that could be put aside, this obviously differing from harvest to harvest. Occasionally, at Barcın, this amount exceeded the amount needed for a year's supply for a family, sometimes considerably. This amount can be seen as a surplus, but probably this was surplus of the kind that Halstead (1989, 68–80) has termed "normal surplus," in the sense of reserves that allow subsistence farmers to protect themselves against crop losses and poor harvests, rather than surplus that can be mobilized socially or politically. It seems that the considerable variation in volumes at Barcın can be well-explained by the normal variation in the size of harvests produced from year to year.

Storage location and residential mobility

Having made the case that the silos at Barcın Höyük represent the stores of individual households, we are confronted with their clustered occurrence in a location away from the dwellings of these households. As described above, there are indications that there may have been dwellings at the foot of the mound, and they may also have stood elsewhere on the mound, but the area of the pits themselves was devoid of recognizable architectural remains.

In its spatial configuration, this layout resembles the silo fields of northeastern Spain (Prats, Antolín, and Alonso 2020b), but it differs completely from the situation observed at the other Anatolian sites discussed, where storage was linked directly to houses. In the case of Çatalhöyük, the location of storage bins in secluded storerooms inside houses was presented as an expression of household "economic autonomy," suggesting that crop cultivation, processing, and storage was done at the level of individual households (Bogaard et al. 2009, 664). Does this mean that the cluster of silos away from the houses at Barcın Höyük is an indication of the opposite—that crop cultivation, processing, and storage was organized at a supra-household level? It seems that while this cannot be ruled out, it is not supported by the evidence for variable but generally "family-sized" silos. It is interesting to note here that Barcın Höyük also yielded a silo of Early Bronze II date that would have held at least 20,000 L and possibly much more. Such a volume seems much more congruent with collectively or centrally organized production and storage.

What considerations could have led to the choice of clustered stores away from the houses? Part of the answer may lie in the practical advantages of an elevated location for underground silos. As moisture is one of the main adversaries of successful preservation of grain in bulk storage (Reynolds 1974; Sigaut 1988), it is critical to prevent water from entering the silo. The top and upper slopes of the Barcın Höyük mound were elevated well about groundwater level and offered easy possibilities to divert rainwater away from the silos. Another practical advantage of storing crops away from houses is that it makes it easier to keep them free from insects and small rodents that occur commonly in settlements (R. Cappers, personal communication 2020). Nevertheless, these considerations do not explain why it was particularly in this period that the choice was made to use underground silo storage outside the settlements but not in other periods when the same advantages would have been offered. We need to take a broader look at the circumstances of the period that may have made this choice favored over others. Here again, the literature on ethnographic cases offers helpful clues.

Comparing different types of grain storage facilities and their applications across cultures, Jiménez-Jáimez and Suárez-Padilla (2019, 18) note that underground silos are particularly favored among small farmers. Silos require relatively little labor investment to construct and maintain. They are very effective in keeping basic supplies and emergency reserves away from various threats. They can be easily concealed from outsiders, especially when constructed away from dwellings. Ethnographic and ethnohistoric studies, moreover, show that underground silos occur frequently among relatively mobile populations and in situations of seasonally abandoned settlements (DeBoer 1988; Jiménez-Jáimez and Suárez-Padilla 2019). As DeBoer describes, many of the societies of eastern North America hid their fall harvests in concealed underground pits during the seasonal abandonment of their aggregated summer settlements (1988, 9, table 1). Underground storage and mobility were so strongly correlated that it makes perfect sense, according to DeBoer, that a phase of full sedentism during the Middle Woodland Period led to the temporary disappearance of storage pits. Social unrest and excessive taxation appear in the literature as additional reasons to use concealed underground storage (examples in Halstead 2014, 161).

This brings to mind suggestions made about Anatolian Middle Chalcolithic societies as being more mobile than their Early Chalcolithic predecessors (Düring 2011). The Middle Chalcolithic evidence for simple huts, as at Ilıpınar and Aktopraklık, and for make-shift, constantly modified architecture, as at Canhasan I layer 1, fit this line of thinking. Permanent settlements, as known from central Anatolian sites like Güvercinkayası (Gülçur 2012), may have existed in northwestern Anatolia, too, in hitherto undetected locations. It is possible that one such settlement existed at Barcın Höyük, outside of the excavated areas. However, the pieces of evidence that are available to date in western Anatolia, limited in quantity but varied in nature, are also understandable as components of a landscape in which the inhabitants were less tied to substantial, permanent settlements than their predecessors had been.

In this scenario, these inhabitants were not nomadic pastoralists without arable farming; the Barcın Höyük silos are clear indication that substantial time and effort was invested in crop cultivation, and that this regularly produced surpluses. Storing grain reserves in clusters of concealable silos, in an elevated location with good drainage properties, would not only have maximized food security but also minimized monitoring requirements. As such, the agricultural economy may well have been organized in such a way that it allowed at least part of the community to be seasonally absent and engaged in different activities in different localities.

Conclusions

An analysis of the early 5th millennium B.C. remains of Barcın Höyük has shown that the excavated sector of the site was used in this period primarily for grain storage. Although no associated botanical remains were found, the storage facilities indirectly demonstrate that cereal cultivation formed a significant part of the subsistence economy. Given the characteristics of underground storage of bulk cereals, it is likely that the silos were used to store stock that was not immediately necessary—that is, the surplus normally produced in years with good harvests.

We should probably see the dense cluster of silos as the outcome of a prolonged use by a small number of households progressively digging, using, and refilling pits. Although showing considerable variation in volumes, a majority of pits were large enough to hold at least the annual staple requirements of a small family. A household-level storage practice is more likely than a scenario of large-scale collective or elite-controlled storage. The choice to locate the silos away from dwellings may have been driven by advantages to the preservation conditions, but its background could also be sought in broader patterns of new landscape uses that emerged at the end of the Early Chalcolithic. It is proposed that isolated silo clusters worked well for relatively mobile communities that purportedly inhabited northwestern Anatolia at the time, allowing for secure storage of staple reserves with minimal monitoring and maintenance. For now, this proposal relies on a combination of cross-cultural observations on underground silo usage among more or less mobile groups and ideas formulated in the literature on the basis of other categories of evidence on mobility in Anatolian Middle Chalcolithic societies, and it should be investigated further.

To date, silo clusters have not featured much in the Anatolian and Near Eastern archaeological literature. Based on the Barcın Höyük case study, I would argue that it is worth paying more attention to them as a way to engage with topics such as the nature, scale, and organization of the subsistence economy, the social and political dimensions of food storage, or the landscapes that people inhabited and used outside the settlements that have been our traditional focus of research. In periods where settlements are well-known, pits can offer a complementary look at ancient communities and their landscapes. For periods where settlements are difficult to recognize and may not have been central elements of the landscape, pit clusters may offer crucial information that cannot be obtained in other ways.

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