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Çaltılar Archaeological Project – archaeological, archaeometric, and ethno-archaeological investigations of pottery production and consumption in SW Turkey

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Introduction: the Çaltılar Archaeological Project

In this paper we present some of the work that we have carried out on the Late Chalcolithic and Early Bronze Age pottery from Çaltılar Höyük (**Figs. 1 and 2**). This is an interesting pre-Classical archaeological site situated in the *yayla*, next to its eponymous modern village, in the district of Fethiye and province of Muğla. The site is located in the upper reaches of the Xanthus river system (modern Eşen Çay), about 10-15 km from the ancient cities of Balboura and Oinoanda, and very close to the modern Antalya-Fethiye highway. An international team, directed by Nicoletta Momigliano, conducted a systematic archaeological survey of this höyük from 2008-2010 (Momigliano *et al.* 2011).

The overall aims of this survey project were 1) to provide substantial new data on the Chalcolithic, Bronze Age, and Early Iron Age settlement history and material culture of northern Lycia; 2) to explore the role of this region within the context of broader Eastern Mediterranean-Anatolian-Aegean interactions in these early periods, and in particular the role of major rivers (such as the Xanthus) as communication routes; and 3) to investigate shifts in settlement pattern in the context of environmental and socio-political changes. We have largely achieved our goals through a systematic survey of Çaltılar Höyük, but we hope that we will be allowed to conduct excavations in the future, because it will be only through systematic excavations of this site that we shall be able to provide clearer and fuller answers to our research questions. The main results that we have obtained so far can be summarised as follows.

Concerning the settlement history or phases of occupation, our work has shown that the earliest ceramic material found on the surface of the site may be assigned to the Late Chalcolithic period (second half of the fourth millennium BC), and substantial occupation continued into the Early Bronze Age (third millennium BC) (**Fig. 3**). It is not clear whether the site was occupied in the Early Bronze Age I, but we have plenty of evidence for extensive occupation during the Early Bronze Age II and possibly Early Bronze Age III phases. In addition, we identified, for the first time in this upland region we identified evidence for

possible occupation in the second millennium BC, i.e. Middle-Late Bronze Age. The ceramic material that can be assigned with some certainty to the Middle-Late Bronze Age is very small in quantity and lacks diagnostic characteristics that could allow more precise dating. Nevertheless, it is very important, because it fills a gap not only in the history of the site, but also of this region more generally, since archaeological remains of the second millennium BC in Lycia and southwest Turkey are relatively rare and not widely known (Momigliano and Aksoy, forthcoming). The following period, i.e. the very end of the Bronze Age and the earliest centuries of the Iron Age (ca. 1200-800 BC) are still a bit of a mystery at Çaltılar, but we have collected a great deal of ceramic material that can be securely dated to the eighth, seventh and sixth centuries BC, suggesting that the site was continuously occupied in these phases. Ceramic finds that can be dated to a period after the sixth century BC do exist, but in very small quantities. This suggests that the end of substantial occupation on the höyük coincided with the Persian annexation of Lycia, related by ancient Greek sources such as Herodotus.

Archaeological, petrographic, and ethnographic investigations at Çaltılar, with special reference to the Late Chalcolithic and Early Bronze Age pottery.

As mentioned earlier, one of the aims of the project was to throw some light not only on the history of the settlement (i.e. the different phases of occupation) but also on the interactions between this settlement and other regions, especially in view of the fact that Çaltılar and the area known as Lycia/lands of Lukka are located at the crossroad between the Eastern Mediterranean, Anatolia, and the Aegean. One way in which we could explore issues of interactions was through establishing the provenance of our ceramic finds, which are our most abundant material. Therefore, one of the first questions we wished to investigate was: what represents local ceramic production and what is imported at Çaltılar?

There are of course many techniques that could be employed to investigate the provenance of ceramics, but we decided to start with ceramic petrography, for a number of reasons. To begin with, petrography is a very powerful, but also relatively cheap and quick analytical method that can shed light on many aspects of ceramic technology, including provenance. In addition, this method is particularly suitable for relatively coarse fabrics (i.e. fabrics rich in inclusions and/or temper), and the vast majority of the pottery collected from Çaltılar Höyük falls within this category. Indeed, for coarse fabrics petrography is arguably a more suitable technique for establishing broad provenances than other analytical methods.

Ideally, of course, one would use a combination of different types of analysis such as petrography and automated SEM-EDS with QEMSCAN® (cf. Knappett *et al.* 2011, Hilditch *et al.* 2012), which can combine the results of analyses of both fine and coarse contents in the clays, and we hope to be able to do this in the future. But for the time being, for the Çaltılar project we have so far analysed our ceramics only through thin-section petrography. Our total sample is relatively small: in total, we collected from the surface of the höyük approximately 33,000 potsherds, and our sample for petrographic analyses so far includes 103 potsherds dating from the Late Chalcolithic (late fourth millennium BC) to the Archaic period (ca. 600 BC) and one fragment of mud-brick from Çaltılar (obviously non datable) (Momigliano *et al.* 2011). Of this sample of 103 potsherds, 38 belonged to ceramics assigned to the Chalcolithic and Early Bronze Age (see **Fig. 3** for some examples of Chalcolithic and Early Bronze Age ceramics, and **Table 1** for list of samples). In addition, we analysed two Early Bronze Age potsherds from Hacimusalar Höyük, which is located in the Elmalı plain, i.e. in the next valley to the east of Çaltılar, but separated by very high mountains (for more details on the analyses see **Petrographic thin section analyses** below). The potsherds from Hacimusalar were kindly provided by the director of the excavations of this important site, Ilknur Özgen (and with the permission of our respective representatives of the Turkish government).

In addition, in our attempt to define what could be produced ‘locally’, we collected and analysed a total of 18 ‘reference’ clay samples, which were taken from the young unconsolidated sediment deposits from the Çaltılar, Seki, Söğüt and Gölhisar basins (**Table 2**; for more details see **Petrographic thin section analyses**).

Finally, we were also fortunate in the fact that traditional pottery is still produced in the village of Esenköy *yayla* (formerly known as Dont), which is located about 10 km south of Çaltılar. This allowed us to compare the fabric composition of modern and ancient pots. We shall discuss further the modern Esenköy potters below: here it will suffice to say that all these analyses of ancient, modern, and ‘reference’ samples have shown that, because of the geology of the area, the pottery produced ‘locally’, and with local raw materials, must contain certain types of inclusions, and in particular inclusions derived from ultramafic rocks such as peridotite and serpentinite typical of the Lycian Ophiolites and the Lycian Mélange of our *yayla* area (cf. also below, section on **Petrographic thin section analyses**).

In our investigations and interpretations of what is local and what is imported ceramic production, we encountered almost immediately a methodological and terminological problem, namely: what do we mean by ‘local’? While discussing the first set of results of our analyses, after the first season at Çaltılar in 2008, it became apparent that, at first, what ‘local’

meant for the ‘scientist’ (Kibaroglu) did not match what ‘local’ meant for the ‘archaeologist’ (Momigliano). For the scholar trained in the ‘hard sciences’ ‘local’ meant something made in Çaltılar itself or in its immediate vicinities. For the archaeologist ‘local’ meant something made within a broader area matching modern ethnographic models, i.e. an area covering the distance that traditional potters, not aided by mechanical means of transport, are prepared to travel to obtain their raw material (e.g. potters travelling on foot or on a donkey). In most communities that have been studied by anthropologists and ethnographers, this distance does not usually extend beyond a radius of 3-4 km, although time is really the most important factor, and this usually means a distance that can be reached within a few hours (cf. e.g. Arnold 1981; 1985, 32-60; Neff, Bishop and Arnold 1991). It also became apparent through our study that, with the data at our disposal, and because of the geology of the Çaltılar area, we could not define ‘local’ in the ‘scientific’ and more restricted way (Çaltılar Höyük and the fields immediately adjacent to it), and that even the broader ‘ethnographic’ definition of ‘local’ as an area with a 3-4 km radius could not be adhered to, because geology similar to that of the Çaltılar basin extends also to other areas such as Seki, which is located in a radius of 10-15 km from our site. In other words, at the moment for us ‘local’ can only be defined as pottery whose fabric composition fits geologically with the Çaltılar basin and appears to be common at the site. But we must also bear in mind that our ‘local’ pottery could include ceramics made at a distance of more than 3-4 km from Çaltılar, in an area that is geologically compatible with the Çaltılar basin, such as the Seki basin. Only further analyses of more samples from Çaltılar and also from other sites in neighbouring areas (e.g. near Seki) could allow us to define our ‘local’ more precisely.

At any rate, the results obtained so far, which combine macroscopic and microscopic observations, are very interesting and show that Çaltılar was a well-connected settlement at least for some of its occupation phases, something that is also indicated by the discovery of one piece of obsidian that comes from Nenezi Dağ in southern Cappadocia, over 400 km away (Momigliano *et al.* 2011, 110 and figs. 54, 58).

Our ceramic analyses have shown that, basically, all the ceramic samples dated to the Chalcolithic period appear to have been locally made, but this does not necessarily mean that all the Chalcolithic pottery found at Çaltılar was not imported from other regions, given that our sample is relatively small: all we can say at present is that the analyses suggest that most Chalcolithic pottery was likely to be made locally. With the Early Bronze Age, however, we were able to distinguish local productions as well as imported materials among our samples. For the Early Bronze Age we were also able to identify a number of distinctive wares at the

macroscopic level. To avoid confusion we should state that by the term ‘ware’ we mean groups of ceramic materials that share the same the surface treatment: for example, ‘dark-burnished ware’, ‘red-burnished ware with white painted decoration’, ‘incised ware’, and so on. Some of these wares are quite common at Çaltılar (e.g. the dark-burnished ware), while others are quite rare (e.g. the red-burnished ware with white painted decoration and the incised ware; cf. **Fig. 3**). On the one hand, much of the dark-burnished ware, which one might suppose to be mostly ‘local’, looks undistinguishable to the naked eye, but the petrographic analyses have shown that this archaeological/stylistic group includes pottery made with very different clays, some of which are not local, and may originate from areas as distant as the Menderes massif region. On the other, the rarity of fragments in red-burnished ware with white painted decoration could suggest that they could all be imports to Çaltılar, but the petrographic analyses indicate that while some pots made with a marly clay are certainly imports, possibly from the Elmalı plain, others appear to have been produced locally, because they are rich in inclusions that are typical of the Çaltılar and Seki basins, such as serpentinite – inclusions that are found in both ancient and modern pottery from these areas (for more details cf. below, **Petrographic thin section analyses**). In other words, there is a certain mismatch between the purely macroscopic, stylistic classifications, and the results of the petrographic analyses, which should make archaeologists very cautious when discussing interconnections and trade exchanges (or lack of them) only on the basis of observations made with the naked eye.

As mentioned earlier, our ceramic investigations at Çaltılar have included investigation of traditional pottery production in the nearby village of Esenköy *yayla* (about 10 km south of Çaltılar, on the modern Antalya-Fethiye highway) – a village that also has its autumn/winter/spring counterpart in the lower valley, located on the outskirts of Fethiye, and we would like to conclude this part of our paper with a brief discussion of our ethnographic research.

Pottery making in this village is a craft that has been carried out by women only, and is usually taught from mother to daughter, or, at any rate, pottery-making skills appear to have been transmitted through female kinship lines. We visited the potters of Esenköy in the summer of 2009 (early September), while they were residing in the *yayla*, and we were able to observe only two phases of their pottery making activities in action: first, the collection of clay from the slopes of the nearby mountains, at a location which was about a 20-minute walking distance from the village; and, second, the making of pottery on the wheel by one potter. In **Fig. 4** we show the general location of the clay source used by the Esenköy potters.

The clay source is residual, derived from ultramafic rocks, peridotite. The clay contains large unaltered mafic rock fragments. The potters sieve first the clay in the deposition area (**Fig. 5a, b**), after they have ground it and let it dry.

Even after sieving, the clay still contains sand-sized fragments. The potters also add two different types of temper, which belong to the same type of rock (peridotite) from which the clay also derives. One of the temper materials is slightly more altered, and appears white-cream in colour (**Fig. 5c**). The other is not very strongly altered, but is still relatively soft and can be grinded.

The pottery is decorated with a characteristic white pigment (**Fig. 5d**) consisting of talc (a phyllosilicate that occurs because of the strong alteration of ultramafic rocks). The talc is diluted with water, and this solution is used to decorate the pottery before it is fired (**Fig. 5e**). After finishing the vessels (**Fig. 5f, g**), these are left to dry in the shade, inside a shed (**Fig. 5h**). One or two weeks later they are fired in a bonfire (**Fig. 5i**).

Although digging for clay and wheel-throwing of pottery were done exclusively by women, men were not totally excluded in the processes, at least as observers. Interestingly, our informants told us that if a woman from Esenköy moved to another village, for example through marriage, she would be sworn to secrecy as to the sources of raw materials, techniques of production, and so on. In other words, the secret of how to make pottery should not be divulged in other villages. Although a few women are still producing pottery in Esenköy (during our visit we observed four women collecting clay in two teams of two women each), it is likely that this craft will vanish in the very near future. Younger generations are no longer trained in this activity, because changing life-habits and socio-economic circumstances do not encourage the continuation of traditional pottery production. More specifically, one of the potters we interviewed told us that her daughter had not learnt and had no intention of learning potting skills, and mentioned the arrival of piped water in their villages as the one of the principal causes for the diminishing demand for her products.

The shapes made by the Esenköy potters include mostly water-jugs, cups, and bowls. This pottery is usually sold in itinerant markets/bazaars, but some can also be found in some shops in Fethiye. The pottery making usually takes place in the summer, but our colleague Pamela Armstrong (of Oxford University) visited a workshop during the autumn/winter months, which was located in lower Esenköy near Fethiye (personal communication). The Esenköy potters we interviewed also confirmed that pottery was sometimes made in the lower village, but that the clay used was usually that collected from the *yayla* in the summer. Archaeologically, this transportation of raw materials would be very difficult to detect, and

would create even more methodological and terminological problems in the definition of ‘local’. But we can, perhaps, assume that this practice was unlikely to have occurred often in antiquity.

Petrographic thin section analyses

1. Aims and methodology.

This section presents in more detail the results of the petrographic analysis of 41 samples including 38 potsherds collected from Çaltılar, one mud-brick fragment also from this site, and two potsherds from Hacimusalar (**Table 1**). The samples comprise various ceramic wares datable to Late Chalcolithic-Early Bronze Age period. The analyses focused primarily on the characterization of the raw materials, the identification of rock and mineral fragments and fabric features, which define different clay sources and help to determine their provenance. The principal aim of these analyses was to characterise petrographically a number of macroscopically defined ceramic wares (for example, red burnished and white painted ware), some of which were suspected to be ‘local’, while others appeared to be imports. In other words, in our study we focused on two key questions. (1) Can we identify and characterise petrographically ‘local’ pottery production/consumption at Çaltılar, in the sense of production/consumption of pottery whose fabric composition is compatible with the geology of the area? (2) Can we identify and characterise imported ceramics, with respect to provenance and technological traditions?

To answer these questions, in addition to the aforementioned 41 samples, we also collected a total of 18 ‘reference’ clay samples, taken from the young unconsolidated sediment deposits from Çaltılar basin (seven samples), Seki (five samples), Söğüt (four samples) and Gölhisar (two samples) (see **Fig. 6** and **Table 2**). The clays from these ‘reference’ samples are fine, or partly very fine with high plasticity: for example, clay samples C-1 to C-3 from Çaltılar are suitable for pottery making. Since they were unconsolidated materials, all clay samples were first fired at a constant temperature of 750–800°C to obtain a ceramic-like hardness, and subsequently thin sections were prepared from them, similar to those obtained from the sampled potsherds. One thin section was also prepared from sands collected from a riverbed close to Çaltılar. Finally, we were also able to make some preliminary comparisons between the ancient pottery samples, the ‘reference’ clay samples, and ceramic production by the female potters from Esenköy *yayla*.

All the samples have been examined using standard petrographic thin section technique. This is a powerful analytical method, widely applied in archaeometric ceramics studies, which allows to make correct identification of material composition, grouping of specimens according to similar microscopic features, identification of possible geological source of the raw materials, and reconstruction of production technology. In addition, it provides data that can help to examine technological change and variation over time and space, choice strategies for procuring the raw materials, and can yield valuable information for a better understanding of ancient societies, their trade, and cultural relations (see e.g. Riederer 2004; Reedy 2008; Peterson and Betancourt 2009).

We prepared thin sections from each potsherds and examined them by standard polarizing microscope. For the preparation of thin sections, a thin slice of pottery is dissected vertical to the surface of the vessel, and polished on one side. The slice is then glued with the polished side on a glass slide by means of an adhesive, e.g. a thermosetting epoxy resin, and then ground down to a thickness of about 0.03 mm. At this thickness the different minerals show characteristic optic properties and accordingly they can be identified under the polarizing microscope (Riederer 2004). In the case of the friable specimens the potsherds are vacuum impregnated with epoxy to stabilise the sample enough to permit cutting and grinding processes (Reedy 2008, 2). The percentage of the rock and mineral inclusions as well as pores in the sherds was estimated using the comparison chart of Rice (1987, 348).

2. Geological setting of Çaltılar

Çaltılar is located geologically in the so-called Lycian Nappes (sheet-like masses of rocks that have moved large distances on subhorizontal surfaces; **Fig. 7**). The rocks clustered into the Lycian Nappes consist of different types originating during the long-standing tectonic regime and are exposed across a large area of southwest Anatolia, enclosed between the Menderes massif in the north and the Mesozoic Age Bey Dağları thick limestone sedimentary rocks (Collins, Robertson 1997; 1998; Robertson 2000). They are divided into three tectonic units: (1) the ‘Lycian Thrust Sheets’, composed mainly of Mesozoic to Early Tertiary carbonates with radiolarian cherts, shales and Paleogene clastic rocks; (2) the Lycian Mélange, i.e. thick chaotic lithologies, interpreted as an accretionary prism related to the subduction of Mesozoic Neotethyan oceanics crust (Robertson 1998), comprising serpentinite, gabbro, basaltic rocks, radiolarite cherts and limestone, clastic sediments (Danelian *et al.* 2006); and (3) the ‘Lycian Ophiolites’, predominantly composed of serpentinitised peridotites, related to the Cretaceous Neotethyan oceanic lithosphere that formed above a subduction zone (Robertson 1998; 2000).

In the surrounding area of Çaltılar and its vicinity are exposed predominantly ultramafic rocks of peridotite and serpentinite of the Lycian Ophiolites and the Lycian Mélange (**Fig. 8**). There are also relatively small limestone blocks enclosed in the Lycian Mélange, outcropped in the northwest and southeast parts of the basin. The second predominant rock types are Jurassic-Cretaceous micritic limestone, calciturbidite, rarely chert, shale and volcanics (Orhaneli formation), exposed especially in Doğanlar and westward, and at Elbis Dağı in the south. South of Doğanlar and north of Altındağ villages, there are outcrops of Jurassic-Cretaceous bedded chert and shale in a limited area. North and northeast of Elbis Dağı, in Güldürgazi Tepe and its vicinity, there are also outcrops of sandstone, claystone, chert, limestone and conglomerate (Karaböğürtlen formation).

3. Results.

The lithological types of the main inclusions and the general paste features observed under the microscope enabled us to reconstruct the main source of rock types of the clay deposits used in pottery making and to assign them to broadly defined source regions. In other words, according to the type of main inclusions, their frequency in the clay matrix, and overall fabric features, the selected samples can be divided into four major groups. These can be divided further into subgroups, according to more detailed petrographic features, as described below. The first three main groups comprise different ware types, while the fourth group is represented by two samples both belonging to a Late Chalcolithic ‘gritty ware’ (see **Table 1**). Groups 1 and 4 can be considered as ‘local’, while Groups 2 and 3 represent ceramics produced at some considerable distance from Çaltılar.

Description of Groups and subgroups

Group 1 (serpentinite group).

Most of the ceramic samples from Çaltılar (and also the mud-brick sample) show similar fabric features and can be included into a broad cluster, called here ‘Group 1’. This comprises different ware types, as shown in **Table 1**. This group is characterised by low clay quality, i.e. silty clay with low clay mineral content and high rock and mineral inclusions (up to 25%).

The characteristic feature of this group is the presence of a large amount of serpentinite fragments either as large grains or fine silt-sized inclusions in the matrix, which suggests that the clays were predominantly derived from serpentinite and/or its unaltered equivalent,

namely peridotite rocks (**Fig. 9a**). Further inclusions are chert and micritic limestone, and to a lesser extent (1–2%) quartz, calcite, pyroxene, olivine, chlorite and plagioclase. The grains are usually sub-rounded, partly angular, fine sand-sized, but single grains can reach up to 1–1.5mm in diameter. Most samples show serial grain distribution in the matrix, and some show well-sorted fine inclusions, suggesting that they are natural in origin. Other samples, however, shows hiatal distribution, including large fragments (e.g. samples CT-14 and CT-19). This suggests that their raw clay was tempered during paste preparation. The clay paste is generally dark, black in colour under the polarised light. Some samples (for example, CT-16, CT-8, and CT-104) display a so-called sandwich-like structure – bright outer margins and dark core: this is most probably the result of firing in a reducing atmosphere with an oxidising cooling stage (see also Nodari *et al.* 2004).

Subgroup 1a: this subgroup includes most of the potsherds in our Late Chalcolithic/Early Bronze Age sample, and represents the typical fabric features discussed above for Group 1, namely silty clay with low clay mineral content and high rock and mineral inclusions (up to 25%), especially presence of a large amounts of serpentinite fragments either as large grains or fine silt-sized inclusions in the matrix (**Fig. 9a**).

Subgroup 1b: the sample CT-19 can be assigned to a separate subgroup for the following reasons: the clay matrix of this sample is characterised by moderate pure clay (less silty particles, high clay mineral content) compared to the other samples. It includes also high quantity of well rounded to sub-rounded large mudstone inclusions (7% in volume), which reach up to 2 mm in diameter. The type of inclusions, especial the high amount of mudstone fragments, and also the clay quality show a different clay source used in its production. However, the presence of inclusions, such as serpentinite, chert, and micritic limestone, suggests that the clay deposit has hinterland geology similar to subgroup 1A, and therefore the clay sources should be close to each other. This difference may be the result of different sedimentation condition and display local variation.

Subgroup 1c: the sample CT-10 can be also be assigned to a separate subgroup because, besides the main inclusions, it also includes quartz sandstone inclusions (4%), and a higher proportion of quartz, calcite (4%) and clay mineral (**Fig. 9b**). The grains are generally well sorted and the sample shows a compact clay paste. The grains are rounded, sub-rounded, and

show sub-hiatal distribution in the matrix. It is not clear whether the coarse inclusions (**Fig. 9b**) were added deliberately during manufacture, since the grains show no clear hiatal distribution in the matrix and also the clay matrix contains quartz grains that obviously have the same origin as the large quartz sandstone grains.

Subgroup 1d: the samples CLT-109, CLT-110 and CLT-111 show petrographic features very similar to each other and can be assigned to this separate subgroup. This is characterised by high quantity of large angular serpentinite fragments, up to 25%, which are also represented in the matrix as small flakes. High amounts of large angular serpentinite fragments and their occurrence in the clay matrix suggest that the clay source is derived mainly from serpentinite/peridotite rocks, due to in-situ alteration processes or deposited very close to the primary rock outcrops. This subgroup shows strong affinities with the clay used for modern ceramics in Esenköy.

Subgroup 1e: This subgroup is represented by sample CT-117, which is characterised by inclusions of chert and serpentinite fragments, both in large quantities. There are no other inclusions (e.g. there is no micritic limestone or quartz). Its clay paste is relatively dense and contains fewer silt-sized fragments than the other subgroups.

Provenance of Group 1: the group-specific main inclusion—serpentinite—plays a key role in establishing the provenance of its wares. The predominantly ultramafic compositional affinity of the inclusions, namely, whether they occur as coarse grain or fine clasts in the matrix, indicates that the clay deposits originated mainly from ultramafic rocks. As discussed above, the main geology of Çaltılar and its surrounding area is dominated by ultramafic rocks and, to a lesser extent, by limestone and chert (**Fig. 8**). This suggests that the clay source(s) of this group is (are) located somewhere within this geological zone, for example Çaltılar, Seki, Gölhisar or in their vicinity (**Fig. 6**). This is also supported by petrographic analysis of the clay ‘reference’ samples from Çaltılar, Seki, Gölhisar and Sögüt, and the evidence from the ceramic production of the modern potters of Esenköy. On the whole, we can regard the samples assigned to this group as representative of ‘local’ production, in the sense indicated above, of pottery that appears to be common at Çaltılar and whose fabric is compatible with the local geology.

Group 2 (marly clay group).

Seven samples can be assigned to this group, and they include different wares, mostly datable to the Early Bronze Age (**Table 1**). The characteristic features of this group are its derivation from calcareous rocks and the absence of serpentinite and metamorphic rocks. Due to the calcareous nature of the source rocks, the clays show marly affinity (e.g. **Fig. 9c**), hence the name of this group. However, the samples classified into this group are not entirely homogenous in terms of their petrographic features and can be assigned to various subgroups, suggesting the exploitation of different clay sources, albeit all located within a geological region dominated by calcareous rocks.

Subgroup 2a: besides the typical marly nature of the clay and inclusions like chert and micritic limestone that are shared by all samples in Group 2, this subgroup shows high quantities of quartz and coarse quartz sand stone fragments. The clay quality, if considered as a whole, is high, i.e. it has a high clay mineral content and low silty particles. Especially coarse inclusions like quartz sand stone grains show a hialal distribution pattern and suggest that they were deliberately added by the potter.

Subgroup 2b: the sample belonging to this group is characterised by fine marly clay paste with low quantity of inclusions (**Fig. 9c**). Main inclusions are micritic limestone, chert, quartz and calcite (**Table 1**). The grains show a serial distribution pattern.

Subgroup 2c: This group comprises three samples that are characterised by a fine clay paste. The samples include large chert fragments in small quantities, showing a hialal distribution in the clay matrix, suggesting that the raw clay was tempered by chert rich sand. Other inclusions are micritic limestone, quartz and calcite.

Subgroup 2d: the sample CT-34 contains chert, quartz and calcite inclusions that are typical of Group 2, but is distinguished by a high quantity of micritic limestone (ca. 23%) (**Fig. 9d**). The clay paste is dense, and the grains well sorted. The grains are rounded or partly sub-rounded, and are fine to fairly large (up to 2 mm). The presence of micritic limestone in the matrix and of chert as fine clasts suggest that they are of natural origin.

Subgroup 2f: samples CT-7, CT-107 and CT-108 all belong the Early Bronze Age red burnished ware with white painted decoration. The first is from our site, and the other two from Hacimusalar. They are characterised by a fine clay paste with a low amount of angular, small micritic limestone inclusions and polycrystalline quartz grains. The clay material seems

to be derived predominantly from micritic limestone. Under the microscope one can see very fine micritic limestone particles embedded in the clay matrix.

Provenance of Group 2: the marly nature of the clay paste in particular and the calcareous inclusions indicate that the clay deposit(s) used in Group 2 should be predominantly derived from calcareous rocks. This, the lack of serpentinite, and the low amount of chert all suggest that the clay in this group does not originate in Çaltılar, Seki, or their vicinity. This inference is also supported by analytical data from the reference clay samples from Çaltılar, Seki, Sögüt and Gölhisar. The Elmalı plain is potentially the location of such marly clay deposits, because the geology there predominantly consists of calcareous rocks and lacks large serpentinite outcrops (cf. **Figs. 6** and **8**). Another possibility could be the eastern part of Sögüt (cf. **Figs. 6** and **8**), where the main geology also consists of calcareous sediments. It is therefore difficult to identify with absolute certainty the provenance of the wares belonging to Group 2. Although Elmalı is the most likely option, further analyses of reference samples and ceramics are needed to reach more reliable conclusions.

Group 3 (metamorphic): the two samples of Early Bronze Age dark burnished ware (CT-6) and grey burnished micaceous ware (CT-112) are distinguished in their fabric features and main inclusions from the other Early Bronze Age wares discussed above, and form our third petrographic group. The group specific inclusions are coarse quartz sandstone, polycrystalline quartz and slate (**Fig. 9e**). Single micritic limestone fragments are also present. Coarse inclusions show a hiatal distribution in the matrix (**Fig. 9e**), and this suggests that they were probably added deliberately by the potters. The sample CT-112 also contains muscovite and can be assigned to a separate subgroup (subgroup 3b). The clay matrix of the sample CT-112 consists of small folded and colourful muscovite flake structures, which is clear evidence of its metamorphic origin.

Provenance of Group 3: The types of inclusion and general matrix features suggest that the clay sources for group 3 were derived from predominantly slate/gneiss or similar metamorphic rocks. This and the absence of serpentinite suggest that the wares of this group were not produced in Çaltılar, Seki, Gölhisar or Sögüt, and this inference is also supported by the petrographic analyses of the reference samples. Metamorphic rocks are known in the western part of Denizli, and in the more western region of the so-called Menderes massif (**Fig. 10**).

Group 4 (chert-rich clay).

Two samples, CT-36 and CT-37, belong to the Chalcolithic/Early Bronze Age ‘gritty ware’, and show sharp differences from the other clay groups and subgroups discussed above. They are characterised by an unusually high proportion of chert inclusions (ca. 20-25%) and a pure clay paste (low silt particles as part of the matrix) (**Fig. 9f**). The grain size of the chert varies from silt size to large grains up to 1.5 mm in diameter. The small grains are generally rounded and sub-rounded, whereas the large ones are angular. This suggests tempering processes during pottery manufacture. The high quantity of chert inclusions suggests that the clay was derived from chert-rich sedimentary rocks.

Provenance of Group 4: one of the clay reference samples collected in Seki (SEKI-4, **Table 2**) shows petrographic features similar to CT-36 and 37. Chert sediments are distributed widely in the region around our site, and very close to Çaltılar itself there are massif chert outcrops. A local origin therefore seems quite likely.

4. Conclusions

The results of thin-section analyses of the (not-datable) mudbrick sample and of the 38 Late Chalcolithic/Early Bronze Age ceramic samples from Çaltılar indicate a number of interesting technological features and also provide information on modes of production.

A clear indication of temper or levigation practice in clay preparation processes is archaeometrically not always easy to establish, especially if the raw clay was coarse and originally contained silt-sized matrix and a high content of coarse rock and/or mineral fragments. Such clay can be deposited under high-energy conditions and therefore contains grains of different size. However the sub-hiatal or hiatal grain-size distribution (Maggetti 1982) that was observed in some samples suggest that the raw clays were at least partly tempered. In addition, the occurrence of the micritic lime stone fragments observed in most samples suggests a firing temperature under 800–850°C, the durability temperature interval of calcite. Finally, the results of our analyses show that at least four major clay sources were used in their production. The fact that the petrographic groups consist of samples from different ware types and periods (**Table 1**) gives some information about the production mode. The use of different clay sources for the same ceramic types or use of the same clay for different ceramics types, the varying inclusion types and quantities, and the low clay quality

may point to a lack of distinct paste recipes for production (Kibaroglu *et al.* 2011) and reflect the absence of a centralised ceramic tradition in Çaltılar during Late Chalcolithic and Early Bronze Age.

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