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Reduce, reuse, recycle? The clay of the Pylos tablets

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Introduction

This paper considers the issue of whether clay was recycled for the manufacture of Linear B tablets, based on the systematic study of the clay fabrics of the Pylos tablets announced at the last Mycenological colloquium.[1] The idea that tablets were not intentionally fired and so tablet clay could be reused to make other ceramic artifacts appears relatively early in Linear B studies. The idea seems to originate with Arthur Evans, who observes that the tablets "were not intended as permanent archives, but as temporary vouchers, which could be 'pulped' when they became obsolete, and the clay used again."[2] John Chadwick was somewhat more explicit about the process: "When no longer required the tablet could be 'pulped' by pounding it to fragments in water, and the clay used again."[3] Over time, the scholarly *communis opinio* has been that Linear B tablets were temporary documents, and that unlike some cases in the ancient Near East, where archives might contain tablets from decades earlier ('dead'), all Mycenaean archives were in active use ('alive').[4] Scholars have asserted that tablet clay could have been, or simply was, recycled, though the argument for this has never been made explicitly. For example, in 2001, John Bennet suggested that tablets were temporary documents, and that "when they had outlived their usefulness, they could

[1] Nakassis & Pluta 2017, 290.

[2] *SM* II, 3. See also *Docs*[1], 37-38, 114.

[3] Chadwick 1958, 16.

[4] Cf. Charpin 2004, 55-56; Driessen 1994-1995, 244; Karagianni 2015, 30; Palaima 2003, 153.

easily be recycled into more tablets."[5] Others have asserted outright that tablet clay was recycled; Angeliki Karagianni, for example, suggests that tablet clay "can be easily recycled and reused by immersing it in water, hand-moulding and re-softening its surface to accommodate the new text—a practice that Mycenaean scribes took particular advantage of."[6]

Because the evidence for this practice has never been systematically evaluated for the Aegean, or for Pylos in particular, this seems like an opportune moment to step back and think about what evidence we do, or do not, have.

Methodology

While petrographic analysis of the Linear B tablets from Pylos is impossible, close macroscopic analysis is beginning to provide insight into their manufacture and the processes leading to their firing and deposition. The current project includes two complementary approaches to understanding the tablets as artifacts, a pXRF (portable X-ray fluorescence) study of the elemental composition of the ceramic matrix, undertaken by Billy Wilemon Jr. and Michael Galaty, and a macroscopic study of the ceramic fabric, undertaken by the current authors and Joann Gulizio.[7] These two different approaches are intended to enhance our understanding of different parts of the tablet production process. The pXRF study is expected to identify clusters of tablets made of clay from the same or similar sources, while one of the primary goals of the macroscopic examination is to understand the ceramics' inclusions, both natural and intentionally added, reflecting decisions made and actions taken after the clay had been acquired.

The distinction is, in practice, sometimes a little less clear. For example, macroscopic examination included color identification using the Munsell system,[8] and while the color of most tablets is unsurprisingly some variety of gray or black, there is one tablet series, the **La** tablets, with coloration that is distinct from the remainder of the corpus. The coloration of fired ceramic fabrics can reflect a wide range of factors, including differences in the clay's mineral content, particularly the pres-

[5] Bennet 2001, 27.

[6] Karagianni 2015, 47.

[7] Nakassis *et al.* 2020; Wilemon *et al.* 2020.

[8] Munsell 2000.

ence, types, grain sizes, and distributions of iron oxides, in addition to their interactions with other organic and inorganic compounds in the clay.[9] The other major contributor to the coloration of fired ceramics is the condition under which they were fired, including time, temperature, and atmosphere,[10] with an oxidizing environment producing a much greater range of colors, and a reducing one producing grays and black.[11] This suggests that at least in some cases, it may be possible for macroscopic examination to identify different fabrics on the basis of color, reinforcing the conclusions of a study from the Classic Maya site of Palenque.[12] In this particular ceramic corpus, however, firing conditions severely impede analysis on the basis of matrix color. Because so many of the tablets were fired in a reducing atmosphere at the time the palace burned, the predominant colors in this assemblage are different values of gray and black, a fact which renders appropriate use of color as a reflection of fabric types difficult or impossible. The uncontrolled nature of the firing resulted in highly variable colors on many tablets. Consequently, each tablet's colors were established as a range, using multiple endpoints, in addition to the color of the core whenever it was visible. All tablets had color ranges established through comparison with a book of *Munsell soil color charts*.[13]

All tablets and sealings were examined macroscopically, and also, as necessary, with a 10x magnifying glass and with a Dino-lite AM4815ZT polarizing microscope (Fig. 1). The proportion of inclusions in the ceramic matrix was estimated, and inclusion types were described in order of decreasing frequency within each tablet, with descriptions including size range, sphericity and roundness, hardness, and color, in addition to potential identification.[14] This method is best at noting distinctive, and especially relatively hard, inclusions such as chert; inclusions with

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9 Rice 2015, 278; Shepard 1976, 16-17.

10 Rice 2015, 278.

11 Rice 2015, 281; Shepard 1976, 21-22.

12 Rands & Bargielski Weimer 1992.

13 Munsell 2000.

14 Inclusions were described with reference to Sanders *et al.* 2017, 123-126. Because the Wentworth scale was used, the term 'sand' refers to particle size rather than rock or mineral content. The term 'very fine sand' refers to anything from 0.0625 to 0.125mm, 'fine sand' refers to anything 0.125 to 0.25mm, 'medium sand' refers to inclusions from 0.25 to 0.5mm, 'coarse sand' refers to anything from 0.5 to 1mm, and 'very coarse sand' includes anything from 1 to 2mm (Wentworth 1922, 381). Due to constraints of visibility, very fine and fine sands were both identified as being fine,' and typically anything larger than 0.5mm was measured with calipers.

distinctive shapes, such as cubic; large inclusion size; variable inclusion colors, especially colors that contrast with gray or black; and high inclusion frequencies. By contrast, inclusions were more difficult to identify when they were close in color to that of the clay, especially if they were relatively matte. This periodically occurred with softer inclusions embedded in surfaces that had been heavily reduced.

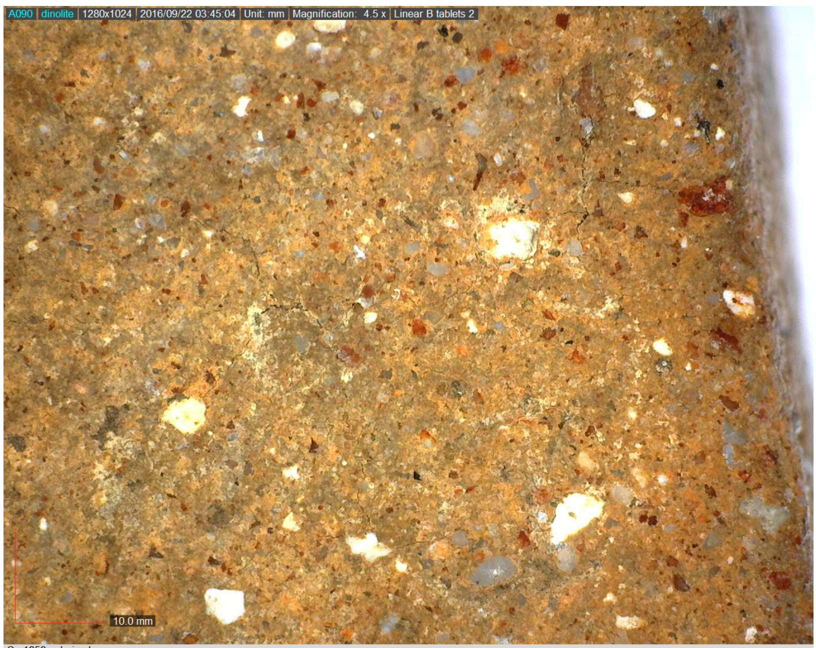

Fig. 1. Photograph of the fabric of **PY Cc 1258**, Dino-lite AM4815ZT polarizing microscope (photograph by Julie Hruby, courtesy of the Department of Classics, University of Cincinnati).

Individual tablets also had characteristics that enhanced or impeded analysis. Tablets were more difficult to evaluate when they were dirty or retained encrustation, often of calcium carbonate. Preservation levels also played a significant role. Inclusions were typically more visible in breaks than on the surface, because cracks had initially propagated from inclusion to inclusion; as a result, intact tablets were more difficult to evaluate than broken ones. The freshness of breaks also played a role, with ancient breaks appearing smoother than newer ones, in part because some had lost inclusions. Whether and how well tablets had been mended also played a role; less heavily mended tablets, and those that had not had gaps filled, simply had more breakage surface area visible, which increased overall inclusion visibility. Sealings and some tablets that were preserved only in small fragments were not large enough to preserve many inclusions, especially if the inclusions were fairly low density.

Recycling

It is useful to differentiate tablet editing or reuse from tablet recycling. There is extensive evidence for the former two categories from the Mycenaean world, including cases where the flat end of a stylus was used to erase signs, or where tablets were wrapped in damp cloth, but much less evidence is available for recycling.[15] Although in Mycenology the practice of recycling has been more asserted than argued, scholars of cuneiform tablets in the Near East have discussed at length whether, when, and to what extent tablet clay was recycled. Xavier Faivre has made a detailed argument for the reuse and recycling of tablet clay,[16] and clay recycling emplacements have been claimed at numerous sites.[17] The recent reassessment of this evidence by Jon Taylor and Caroline Cartwright has suggested that "while it seems safe to assume that some recycling of tablets did take place, the evidence for it is very limited, and evidence of its absence exists."[18] Raw clay is ubiquitous and easily accessible, whereas "recycling involves unnecessary effort."[19] Even in school contexts, where tablets go out of use as soon as they have been created, there is a great deal of evidence for tablet discard.[20] Taylor and Cartwright also make the critical point that inclusions in clay would tend not to survive levigation or soaking, as larger inclusions would sink to the bottom of the vessel in which they were being submerged and would, therefore, not appear in the final clay body.[21]

Close examination of the Pylos tablets reveals that the clay is highly variable in quality and is, on the whole, much less fine than Near Eastern non-school-text tablets. With a few exceptions, it is difficult to be certain which inclusions were intentional temper and which were

[15] See Judson 2020, with references.

[16] Faivre 1995.

[17] Robson 2019, 37.

[18] Taylor 2011; Taylor & Cartwright 2011, 318.

[19] Taylor 2011, 21.

[20] Taylor 2011, 21-22.

[21] Taylor & Cartwright 2011, 315.

naturally occurring in the clay, but very little if any of the Pylian clay has been finely levigated. There are cases where Near Eastern tablets do have inclusions, but they seem to be consistently smaller. Taylor points out that tablet clay from Old Babylonian Tell ed-Der was "levigated to a stage where inclusions were < 0.01mm, but unsoaked fragments up to 3mm remained."[22] By contrast, inclusions at Pylos can reach 14mm (Fig. 2). Taylor points to tablets from Nuzi and a Canaanite tablet found at Tell el-Amarna as having unusually large inclusions, and while measurements are not given, those shown in a photograph seem quite small, based on the text size, compared to what we see at Pylos. The Amarna tablets, with points of origin throughout the Eastern Mediterranean, typically have either no inclusions (see the Babylonian tablets in particular) or inclusions described as 'sand' (i.e., usually referring to grain size, so according to the Wentworth scale,[23] reaching less than 2mm; in fact, they seem to refer to much finer material than that), though they occasionally also include what are described as very small stones (e.g., quartzite from the Hittites reaches 0.7mm).[24] Taylor does point to Neo-Babylonian school tablets as being "full of stones and shells, indicating insufficient levigation"; it is unsurprising that the clay for school texts would be less well prepared.[25] In all of these cases except perhaps the Neo-Babylonian students' texts, the purity of the clay compares extremely favorably with that of the Pylos tablets.

Goren and colleagues argue that "as tablets cannot be too gritty, we may expect the inclusions to be sieved, thus preserving only the finer fraction and eliminating rock types and minerals that appear in the coarser fraction of the sand."[26] At Pylos, however, the clay fabrics of the **Ad** tablets are coarse enough that they were clearly never sieved (Fig. 2). The chert inclusions from the fabrics of the **Ea** tablets, by contrast, are sufficiently regular in shape and size that these tablets probably were intentionally tempered, perhaps uniquely among the Pylos tablets (Fig. 3). Goren and colleagues divide inclusions into 'artifact inclusions,' i.e., intentionally added temper, and 'ecofact inclusions,' or those naturally mixed with the clay. They suggest that "if artifact inclusions do appear,

[22] Taylor 2011, 6.
[23] Wentworth 1922.
[24] Goren *et al.* 2004, 31-37; Wentworth 1922.
[25] Taylor 2011, 7.
[26] Goren *et al.* 2004, 7.

it may be suggested that the local pottery workshop's clay had been applied for tablet production."[27] That seems not to be the case at Pylos, however; the chunky **Ea** tablet fabric does not correspond to any known local pottery fabric. Almost all **Ea** tablets had inclusion densities above 10% and many around 25%, so that the writing surfaces were coarse and challenging to inscribe (Fig. 3).

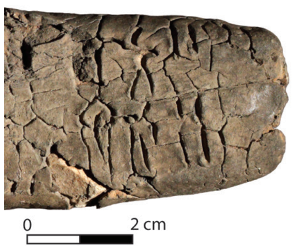

Fig. 2. Photograph of right part of **PY Ad 671**, showing large (14mm) chert inclusion (photograph by Pylos Tablets Digital Project, courtesy of the Department of Classics, University of Cincinnati).

Fig. 3. Photograph of left part of **PY Ea 28**, with break revealing fabric with inclusions; color saturation was increased to make inclusions more visible (photography by Pylos Tablets Digital Project, courtesy of the Department of Classics, University of Cincinnati).

While a tablet blank and twists of well-kneaded clay for making administrative documents, perhaps sealings as well as tablets, have been found at Pylos,[28] there is no obvious settling tank or jar for the production or recycling of tablets on site. Carl Blegen and Marion Rawson report no appropriately sized structures or vessels from Room 7 or the floor level of Room 8.[29] The pithos in Room 7, sometimes suggested to have been a potential water source for tablet production, was probably not used to hold or recycle clay.[30] First, Blegen and Rawson believed it to have held olive oil that, once the pithos had broken, fueled the fire in the Archives Complex.[31] While the basis for that belief is not self-evident (they clearly did not have residue testing done), it is nonetheless plausible. The contents of Room 7 did indeed burn in an unusually hot, reducing fire, of the variety we might expect from burning olive oil, as the sintered,

[27] Goren *et al.* 2004, 7.

[28] Blegen & Rawson 1966, 99, 136, 137, Pl. 276.

[29] Blegen & Rawson 1966, 92-100.

[30] Palaima 2011, 150; Pluta 1996-1997, 240, 246, 247.

[31] Blegen & Rawson 1966, 92.

blackened aspect of the tablets from this context should indicate. Additionally, it is possible for excavators to smell olive oil, even thousands of years later, as those at Palaikastro discovered.[32] We should consider the possibility, then, that Blegen and Rawson might have identified the contents of this vessel accurately. More to the point, the pithos was simply too big to be used for levigating or recycling clay; while its capacity was not measured, it was described as 'enormous,' and based on its dimensions, it should have had a capacity of well over a cubic meter.[33] At 1.64 m tall, it would have been difficult to reach its contents without a stepladder and nearly impossible to reach the bottom even with one.[34]

A few scholars have suggested that it might be possible to recycle a tablet simply by immersing it briefly in water.[35] We do not have any clear evidence for this having happened at Pylos, where the tablets are consistently made from a relatively dry clay, with some notable exceptions.[36] Our experience is that wetter clays tend to have a 'mushy' appearance and may have drip marks or circular rings where they were touched.[37] Karl-Erik Sjöquist and Paul Åström do observe that the Knossos tablets were substantially wetter when they were made than the Pylos tablets;[38] not having had the opportunity to observe the Knossos tablets firsthand, we withhold judgment on whether they can have been recycled through immersion. However, based on the results of Sjöquist and Åström's experimentation with recycling, we would hypothesize that only very recently formed texts would be sufficiently moist to be recyclable using this method.[39]

Most scholars envision tablets being recycled much as Chadwick did; unwanted tablets are collected, either slowly over time or in bursts as tablets on specific topics go out of date. They may be either crushed and then rehydrated, or soaked at length, then the clay is reused. This process is less straightforward or easy than some would assert; Sjöquist and Åström found experimentally that even unfired tablets became in-

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[32] Cunningham 2007, 38.

[33] Blegen & Rawson 1966, 92.

[34] Blegen & Rawson 1966, 394.

[35] Karagianni 2015, 47; Palaima 2011, 105.

[36] Palaima in Sjöquist & Åström 1985, 103; Palaima 1996.

[37] Cf. Sjöquist & Åström 1991, 21, Figs. 18-19c.

[38] Sjöquist & Åström 1991, 11.

[39] Sjöquist & Åström 1991, 23-24.

creasingly hard over time, and that in order to effect recycling, a one-to three-hour soak would have been required, followed by kneading with water, and that "sometimes it was necessary to repeat this procedure several times before the tablet acquired a uniform consistency suitable for writing."[40] They concluded that "it must be more laborious to rework old, dry tablets for reuse than to make new tablets with fresh clay. A shortage of fresh clay might motivate such reuse."[41] In the case of the Palace of Nestor at Pylos, clay shortages seem highly unlikely; the palace is in a region with extensive clay deposits, including some immediately at hand, and even clays that were insufficiently plastic to be suitable for pottery production would have sufficed for tablets.[42] Shortages seem especially unlikely when one considers that compared to their contemporaries in the ancient Near East, Mycenaeans produced extremely small quantities of tablets.

If recycling were widespread, we would expect the macroscopically visible suites of inclusions to overlap substantially from tablet to tablet and series to series; we would also expect not to see large or heavy inclusions. However, overlapping suites of inclusions can have other causes as well, such as overlapping lithic detritus in the natural geologies of the locations where the clay was formed or acquired, or clay mixing before tablets were made in the first place, or cross-contamination of clays through reuse of vessels for levigation or soaking, or of surfaces for working. In other words, macroscopically identifiable inclusions are better suited for identifying cases where recycling probably did not occur than for identifying cases where it did.

In the case of specific tablet series, we can say that it is highly unlikely that the clay had been recycled. The idiosyncratic chert inclusions both in the **Ad** series, with its surprisingly large examples, and in the **Ea** series, with its uncommonly densely packed inclusions of consistent size, angularity, and roundedness, are particularly unlikely to have been recycled. The **Aa** tablets, with consistently very low inclusion frequencies, are also unlikely to have been recycled, as are the **Ac** tablets, all of which have fine sand as their primary inclusion (no **Ac** tablet has more than one non-sand inclusion visible). All six **Cc** tablets have chert, sand, and calcium carbonate. Thirty-six of the 69 **Eb** tablets with at least

[40] Sjöquist & Åström 1991, 23-24.
[41] Sjöquist & Åström 1991, 24.
[42] Galaty 2010.

approximately identifiable suites of inclusions have chert and sand; the quantity of chert is not consistently high, and another 12 are identified as having sand but tend to have very poor inclusion visibility, suggesting that other inclusions may exist. This implies that most or all of those particular tablets may have come from a single batch of clay that had probably not been recycled.

Of the 15 **Es** tablets, eight have been identified as having mudstone/siltstone, sand, and chert, six tablets have mudstone/siltstone and sand, and one has only sand; given the constraints of visibility, these may well all represent a single production batch that was not recycled. The earlier tablets from the Throne Room, most of them **La** tablets, with their distinctively intense matrix coloration and consistent suites of inclusions, with subrounded chert in sizes up to 3mm, mudstones/siltstones, and fine sand, are also unlikely to have been made from recycled clay. The **Qa** tablets also have consistently fine fabrics, typically with fewer than 2% visible inclusions; the fabrics were all sandy, with fine or fine to medium sands, and other inclusions were extant but infrequent. Again, these were probably produced from a single batch of clay which had not been recycled. The **Sh** tablets also look like a more or less unified set: ten of 12 examples have either chert and sand, or chert, mudstone/siltstone, and sand, while the remaining two have chert, calcium carbonate, mudstone/siltstone, and sand. The two tablets with calcium carbonate inclusions, **Sh 743** and **Sh 744**, are otherwise similar to the other texts in the series. The **Sh** tablets are one of the few series in which palm-leaf shaped tablets exhibit a botanical void that apparently represents a straw around which the tablet was formed, and **Sh 743** and **744** are formed around a straw just like the other members of their class.

This is not to say that our study of the fabrics is entirely incompatible with recycling. In general, the more different types of inclusions are in a matrix, the more plausible recycling becomes as one possible cause, simply because if different clay types are recycled together, their inclusions should be combined. The **Cn** series has a much higher level of variability in fabric types than most Pylian series, including four tablets (**Cn 418**, **702**, **1059**, **1197**) that had all available inclusion types: chert, mudstone/siltstone, calcium carbonate, and sand. Tablet **Fr 1251** also has chert, sand, mudstone/siltstone, and calcium carbonate inclusions: it too is a candidate for having been recycled, though it could equally well simply have been made from clay that initially and naturally had this range of inclusions, or from a blended clay with the same range of inclusions, or perhaps it was made in a context in which different clay types had been used previously and not cleaned up. However, the fact that several of these tablets have fairly large inclusions (**Cn 202**, **286**, **328**, **437**, **453**, and **702** all have inclusions reaching 4mm) suggests that even they may not have been made from recycled clay.

Conclusions

The evidence gathered by this study hardly eliminates the possibility that recycling was practiced. Yet we are struck by the fact that the evidence taken as a whole is fairly ordered and presents us with comprehensible patterns, despite its limitations. Our impression is that tablet formation is for the most part a highly structured process, with many series having fairly consistent inclusion types and suites of inclusions. This suggests that tablets were usually made in coherent batches, an impression that the pXRF data also give.[43] It is interesting to observe in this connection that many of the Pylian texts show evidence for being palimpsests. We might consider the relative scarcity of evidence for recycling in our study, combined with the presence of more than 100 palimpsests,[44] to indicate that reusing tablets was far more common than recycling and refashioning, especially since the former certainly seems more practical. On occasion we can point to this playing out in specific examples: for instance, the **Ac** tablets are extremely consistent in terms of their inclusions, and these texts are also all certainly or probably palimpsests according to José Melena. Of the other series that we suggested were made of a single batch of clay (**Aa**, **Ad**, **Cc**, **Ea**, **Eb**, **Es**, **La**, **Sh**, and **Qa**), all but one (the **La** series) have at least one text with evidence for being a palimpsest, and a number of these series have a large number of palimpsests.

If tablet production is a structured process, this does not imply that it produced homogeneous results. In fact, it is worth noting that there is a high level of variability in the combinations of inclusions. Indeed, there is substantially more heterogeneity in the Pylos tablets than there is in

[43] Wilemon *et al.* 2020.

[44] In *PT*[3] Melena identifies 152 tablets with evidence of being palimpsests, with 94 being certainly identified as such and 33 probably.

ceramic vessel fabrics from the palace.[45] The reasons for this phenomenon remain unclear to us, but several possibilities present themselves. First, as mentioned above, clays that were unsuitable for pottery production seem to have been acceptable to Pylian tablet-writers. Second, it might be that tablets were being made in multiple parts of the territory and brought to the palace for information processing and storage.[46] Certainly at least one Pylian text (**Eq 213**) refers to an administrator, perhaps the tablet-writer himself, traveling beyond the palatial center to collect information.[47] Third, it is possible that more individuals were responsible for making tablets than making the pottery found at the palace: Sjöquist and Åström identified ten individual palmprints on only 47 tablets out of what was then 1,112 tablets and fragments, compared to perhaps 10-20 full-time potters (or the equivalent) working in Messenia as a whole, and perhaps only four contemporaneous potters whose work appeared at the palace.[48] A related question is whether tempers were being added intentionally to tablet clay. The nature of our evidence makes it difficult to answer this question conclusively, but we think that it is likely in some cases. For instance, in many of the **Ea** tablets angular chert makes up *c.* 25% of the matrix (perhaps up to 33% in **Ea 439**). We cannot understand why this should be the case — why add so many inclusions, especially ones that have the potential to interrupt a smooth writing surface? —but it is difficult to explain the quantity and regularity of such inclusions in any other way.

Although our argument has been mainly negative with respect to recycling, our findings suggest that tablet production is a far more interesting area of study as a result. Pylian tablet-makers were doing far more than just making, reusing, and recycling tablets. As our colleagues in Assyriology have demonstrated, there is a great deal more to be learned from the physical properties and material histories of our texts.

[45] Cf. Galaty 1999, 50.

[46] Cf. Hallager 2017.

[47] Bennet 2001.

[48] Sjöquist & Åström 1985; Palaima 2011, 83-85. On the number of potters, see Hruby 2006, 199-203, *pace* Whitelaw 2001.

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