Contextualizing Mycenaean Hoards: Metal Control on the Greek Mainland at the End of the Bronze Age

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This paper considers the Mycenaean metallurgical industry at the end of the Bronze Age through analysis of metal hoards and the tools found within them. An overview of second-millennium hoards from Crete and the Greek mainland is presented to contextualize the various objects from these assemblages. Patterns of implement inclusion reveal a repeated tool grouping in seven Mycenaean hoards, most associated with elite contexts. These Mycenaean caches, incorporating a range of complete and broken items, are traditionally considered recyclable scrap, but they need not be random accumulations. The repetitive tool grouping suggests a structural principle in hoard formations, perhaps dictated by the state. The Mycenaean assemblages from the late 13th or early 12th century B.C.E. highlighted here may represent either palatial stock within a citadel or an archaeological remnant of a metal *ta-ra-si-ja* allotment given to a smith. The identification of several hoards as metal disbursements from a palace complements the picture of Pylian administration of metal, attested only by the *ta-ra-si-ja* arrangements outlined in the Jn and Ja Linear B tablets.[1]

INTRODUCTION

Metal hoards from the prehistoric Aegean regularly date to periods of socioeconomic and political tension, specifically the end of Neopalatial Crete (mid 15th century B.C.E.) and the collapse of the Mycenaean palaces on mainland Greece (late 13th to early 12th centuries B.C.E.).[2] Although such instability may increase hoarding tendencies, caches appear in nontransitional periods as well. Diverse social, political, and economic factors may have impacted the assembly of caches or how they entered the archaeological record, yet the habit of hoarding should be considered, foremost, a natural inclination to collect, group, and store one's possessions together. Stockpiling copper and

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[2] Catling 1964, 278–98; Desborough 1964, 47–50; Branigan 1969; Spyropoulos 1972, 210; Knapp et al. 1988, 233; Borgna 1995; Soles 2008; Lantzas 2012, 95–9.

copper alloy objects throughout the Aegean began in the Early Bronze Age (EBA) with notable assemblages from the Cyclades.[3] The extent of the phenomenon is impressive during the late third and early second millennium B.C.E. Wengrow notes: "It is towards the later end of that period that hoards of copper and bronze objects appear across a large area of temperate Europe, from the Middle Danube to the shores of the Baltic Sea."[4] Hoarding became more prevalent in the Aegean by the latter half of the second millennium B.C.E.—the Late Bronze Age (LBA)—on Crete and the Greek mainland (fig. 1; appx. on AJA Online).

What constitutes a metal hoard varies from scholar to scholar, so the definition employed here necessitates explanation. "Hoard," "cache," and "assemblage" are employed interchangeably in this paper, yet those terms should not be confused with "treasures," which contain predominantly precious items of gold or silver.[5] Copper alloys retain metallic value in their own right, but an Aegean assemblage of precious metal objects reflects a different phenomenon than that of collecting copper and/or bronze. Here, groups of nonprecious metal objects from nonmortuary contexts comprise a hoard. Funerary contexts are excluded here because metal objects in a burial ensemble represent a depositional practice different from that of metal hoarding.[6] The term "hoard" is, in fact, unsatisfactory for Aegean assemblages, for it connotes the deliberate concealment of wealth, akin to large coin caches found in later Greco-Roman contexts. The word, however, is so ubiquitous in scholarship that its elimination is unlikely, and no attempt is made to avoid it here. Metal assemblages may have been in storage, buried in the ground, or hidden deliberately. The deposition of hoards may have been purposeful or by chance, and hoards may represent single deposits or gradual accumulations of metal (particularly in the case of assemblages in storage). Bradley's understanding of European Bronze Age hoards as "collections of buried objects that were apparently deposited together on the same occasion" is thus more restrictive than the parameters outlined here.[7]

Given the Aegean's limited copper sources, its dearth of tin ores, and the primary challenges of metalworking (e.g., mining, smelting, and casting), the collection and protection of copper alloy objects are no surprise. Traditional viewpoints about Aegean hoards advocate the haphazard assembly and concealment of metal in response to unstable sociopolitical situations.[8] Take, for instance, Mylonas' interpretation of a metal assemblage found within the citadel of Mycenae: "The objects were evidently hidden there for safekeeping before an impending attack of the enemy by a Mycenaean who hoped to survive and regain his possessions."[9] Are hoards indiscriminate accumulations of metal gathered and hidden during periods of social or political upheaval?[10] Such rationalization ignores the functionality of individual objects, implying that the only value at deposition was a metallic one. This logic permeates much of the scholarship on hoards and explains why many interpretations characterize entire assemblages as intended for melting and recasting (e.g., foundry caches).[11] An alternative viewpoint suggests hoards reflect ritualistic activities primarily.[12] This paper differs from these approaches and evaluates the implications of individual components within hoards rather than attempting to explicate the phenomenon of collecting metal in the Aegean as a whole.

The apparent proliferation of hoards at the end of the Bronze Age is striking, for it coincides with the collapse of the Mycenaean palatial system. The abundance of caches, however, only verifies the instability of that period, which was as much economic as it was political and social. Bradley noted: "Peaks in the frequency of such deposits tell us most about the conditions under which these collections were lost. . . . We have less idea of why they were hidden in

[3] Branigan 1969, 1974; Knapp et al. 1988, 234–35; Fitton and La Niece 1989.

[4] Wengrow 2011, 137–38, fig. 11.1.

[5] Laffineur 2006, 37–8.

[6] For examples of large quantities of copper or copper alloy objects in funerary contexts, consider the Tomb of the Tripods at Mycenae and the early second-millennium burials from the northern coast of Cyprus; see Onassoglou 1996; Keswani 2005.

[7] Bradley 2013, 122.

[8] For discussion about this argument in the Aegean and beyond, see Spyropoulos 1972, 210; Knapp et al. 1988, 233–35, 258; Borgna 1995, 8–11; Iakovidis 2006, 175; Bradley 2013, 122.

[9] Mylonas 1962, 406.

[10] Cf. Catling 1964, 298; Soles 2008, 156.

[11] Desborough 1964, 48; Knapp et al. 1988, 254; Borgna 1995, 12; Harding 2000, 354–55.

[12] Matthäus and Schumacher-Matthäus 1986; Knapp et al. 1988, 250–57; Borgna 1995; Wengrow 2011, 138.

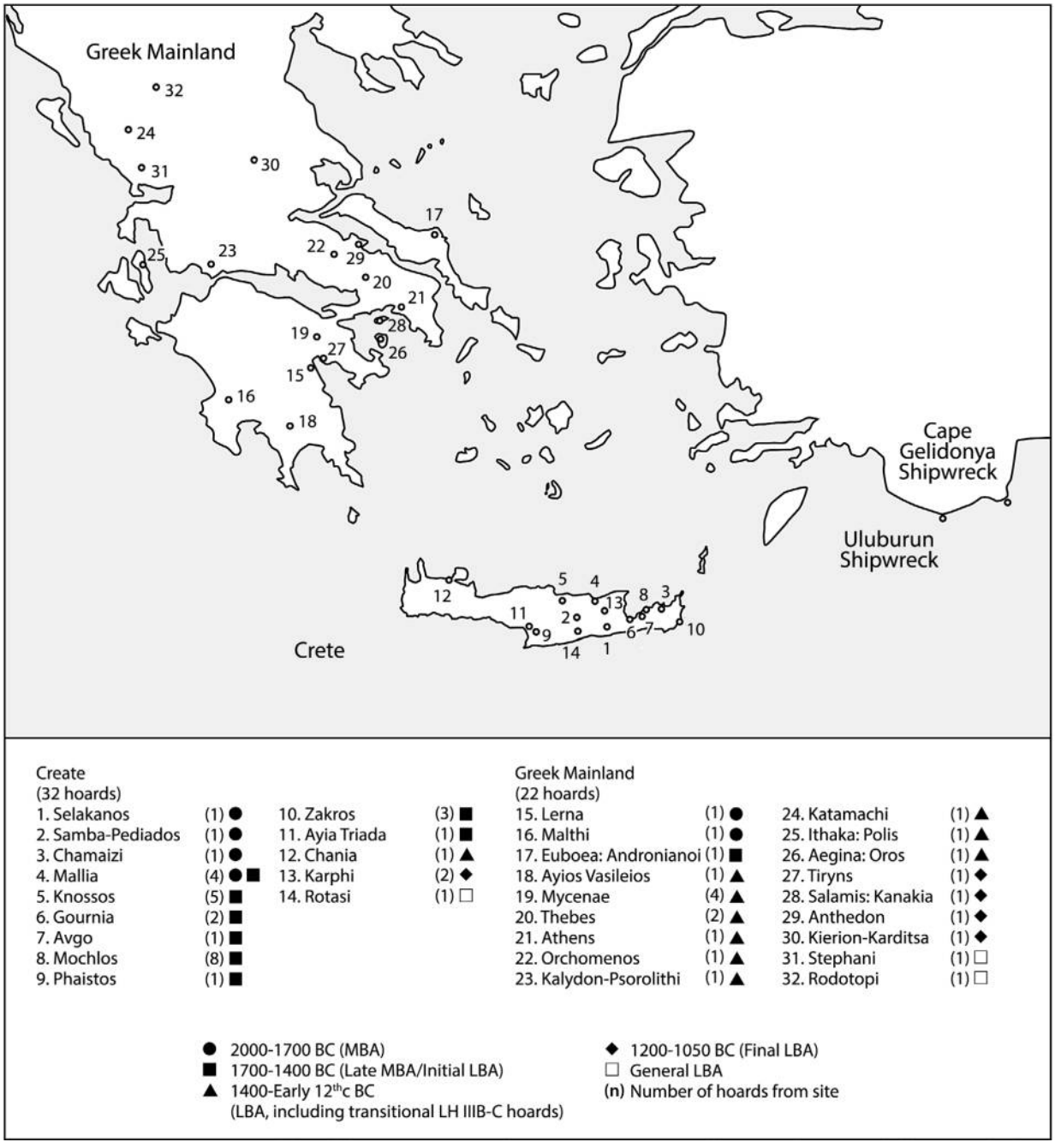

FIG. 1. Distribution map of Middle Bronze Age and Late Bronze Age Aegean metal hoards (drawing by T. Ross).

the first place."[13] The explanation for a hoard's preservation in the archaeological record need not coincide with the reasons behind its formation. In discussing the plethora of hoards from northern Europe, Harding cautioned against the "assumption that political unrest led to the practice of burying metal in the ground," noting that "such connections are tenuous" in specific regions.[14] Turmoil might ensure a hoard's preservation in the archaeological record but is not necessarily the impetus for the assemblage's creation. Lantzas has proposed that hoards from Mycenae on the Greek mainland represent excess materials deposited by traveling smiths.[15] Alternative interpretations to the scenario of stockpiling metal in response to danger thus exist. Complicating the Aegean data set is the imprecise depositional date for many of its LBA caches. Chronological assignments are difficult when contextual details are scanty, as in the cases of chance discoveries and the inadequate documentation of early archaeological fieldwork.[16] Numerous caches lack useful stratigraphic information. Scholars, however, have assigned the majority of the mainland assemblages to the late 13th or early 12th century B.C.E., dating some hoards precariously by tripod or cauldron leg fragments (e.g., the Kalydon, Orchomenos, and Anthedon hoards; see online appx.).[17]

Metal production and consumption played essential roles in the Mycenaean economy, but questions abound regarding the level of palatial control and the provision of copper and tin throughout the LBA.[18] In considering Mycenaean metal hoards, Iakovidis rightly noted that damaged objects must have been recycled all the time and that the collection of such material on its own does not signify a shortage.[19] The Linear B records from Pylos taken together with the mainland hoards, however, do seem to indicate that metal resources on the Greek mainland, though not necessarily on Crete, declined by the late 13th century B.C.E. Such a situation would likely create an economic environment in which metal was gathered, stored, and more closely monitored than in previous periods. Evidence for the Mycenaean metallurgical industry derives primarily from palatial scribes at the Palace of Nestor at Pylos who supervised and recorded the distribution of metal to semidependent smiths (in the Jn and Ja tablets). This allocation system, known in Linear B as *ta-ra-si-ja,* is attested for the dissemination of other materials beyond metal including wooden wheels at Knossos (So tablets) and cloth at Pylos (La tablets), Knossos (L tablets), and Mycenae (Oe tablets).[20] Wool and metal were ideal allocation goods since authorities could track their weights quantitatively.[21]

Only the Pylian tablets, from the end of the 13th century B.C.E., presently testify to the palatial control of metal.[22] Comparable supervision is detectable elsewhere, likely in response to a shortage of copper and bronze. Taking the Linear B tablets into account, this paper re-examines the management of Mycenaean metallurgy through the investigation of archaeological remains, specifically metal assemblages. To contextualize and highlight the unique traits of the late 13th-century caches, it reviews hoarding throughout the second-millennium Aegean. Study of the individual hoard components underscores the propensity to stockpile implements and illustrates how certain Mycenaean foundry hoards imply an oversight of metal by some Mycenaean palaces. Despite their prevalence in the archaeological record, Mycenaean bronze objects

[13] Bradley 1990, 20–1.

[14] Harding 2000, 355.

[15] Lantzas 2012, 103.

[16] Muhly 2009, 24.

[17] Catling 1964, 297; Desborough 1964, 48–50; Knapp et al. 1988, 247–48; Lantzas 2012, 95, table 45.

[18] Killen 2008; Michailidou 2008; Brysbaert and Vetters 2015, 163.

[19] Iakovidis 1982, 226.

[20] Killen 1987; Uchitel 1990–1991; Smith 1992–1993; Nosch 2006, 175, table 2; Shelmerdine 2008, 143.

[21] Montecchi 2012, 191.

[22] How extensive was the *ta-ra-si-ja* system? Despite the lack of evidence for metal allotments beyond Pylos, it is not unreasonable to surmise that other Mycenaean centers participated in *ta-ra-si-ja* metal arrangements. In comparing bronzeworking at Knossos and Pylos, Killen (1987, 69) suspected, on the basis of bronze artifacts at Knossos, that metal allotments were part of the Knossian administrative system. This conclusion is bolstered by similarities in Mycenaean administration, summarized by Killen (1987, 61): "So close, indeed, are these similarities [in Mycenaean management] that it is usually safe to assume, even when no information about a particular aspect of the palace's workings has been preserved at one site (Palace A), but where we do have information about it at a second site (Palace B), that what holds good for that activity at Palace B would also have been found to hold good for it at Palace A, had the relevant records there been preserved." For a more skeptical viewpoint on the application of a metal *ta-ra-si-ja* system beyond Pylos, see Gillis 1997, 505. Nosch (2006, 175), however, has argued for a "pan-Mycenaean system" for *ta-ra-si-ja* work in relation to the textile industry.

have not previously been considered prospective *ta-ra-si-ja* items. Several mainland metal caches, however, seem to represent either palatial stock or allotments distributed by centralized authorities.

THE GREEK MAINLAND'S SUPPLY AND CONTROL OF METAL DURING THE 13TH CENTURY B.C.E.

The question of a metal shortage in the late 13th century B.C.E. revolves around interpretations of metal hoards, scrap metal, and Linear B texts. Fluctuations in the supply and availability of Cypriot copper, tin (perhaps from as far away as Deh Hosein, Iran), and recyclable bronze must have influenced hoarding behavior in the Aegean.[23] Debate persists about whether clusters of hoards in the LBA imply an abundance or dearth of metal.[24] The use of scrap metal, for instance, might reflect an expansion of the metal industry rather than constriction.[25] The quantity of LBA bronze objects, furthermore, in the Aegean and eastern Mediterranean does not hint at an impoverished and declining metallurgical industry.[26] The Mycenaean hoards, however, cannot be disentangled from the issue of metal supply or the socioeconomic changes at the end of the period. The conversation regarding the availability of metal may be advanced if regional variation becomes the focus rather than the search for Mediterranean-wide patterns.

The Uluburun and Gelidonya shipwrecks off the southern coast of Turkey (see fig. 1) provide dramatically different snapshots of international trade during the 14th century and the late 13th century B.C.E.[27] While the Uluburun wreckage yielded 354 copper oxhide ingots along with other ingot types and one ton of tin, the Gelidonya vessel carried a mere 34 oxhide ingots. The Uluburun ship parallels the state-level exchanges attested in the mid 14th-century Amarna tablets.[28] The Gelidonya ship, in contrast, from the late 13th century, carried a fair amount of bronze scrap, notably broken agricultural tools, in addition to copper ingots. By comparison, scrap material was rare on the Uluburun ship.[29] Gelidonya's small cargo likely reflects private entrepreneurialism that became more visible archaeologically by the end of the LBA and during the Early Iron Age (EIA).[30] A flourishing 13th-century market for scrap developed alongside that of bulk copper in the Aegean and eastern Mediterranean. Metal trade at this time thus included raw copper and recyclable bronze products—a more complex industry than the high-level exchanges reflected by the Uluburun shipwreck and Amarna tablets.[31] The advent of an international market for scrap copper and bronze emerged, perhaps, from an inability of Cypriot copper to satisfy ever-growing demands for the material throughout the Mediterranean.[32] Sherratt argued for extensive circulation of bronze in the 13th-century Mediterranean stemming from entrepreneurial trade in European and/or Italian bronze objects and ubiquitous scrap metal.[33] The prospect of a copper or bronze shortage may not apply to the entire LBA Mediterranean, and it would certainly be difficult to prove on Crete and Cyprus.[34] However, Mycenaean contexts from the Greek mainland may indicate a substantial decline in the availability of copper and bronze there.

A disruption to copper supplies could have impacted the mainland's metallurgical industry and forced palaces to ration their stock.[35] Cypriot copper

[23] For an insightful discussion of tin sources in the Bronze Age, see Pigott 2012.

[24] Muhly 2003, 292.

[25] Knapp et al. 1988, 257–58. In discussing the Mycenaean evidence from the Pylian Linear B tablets, Muhly (1992, 18) stated: "There is nothing here to support any theory of a metal shortage." Sherratt (2000, 83) likewise does not envision a bronze shortage in the eastern half of the Mediterranean at the end of the LBA.

[26] Knapp et al. 1988, 257; Muhly 1992, 18.

[27] Bass 1967; Pulak 1988; Bass et al. 1989; Sherratt 2000; Yalçin et al. 2005; Muhly 2009, 21–30.

[28] Moran 1992.

[29] Cf. Knapp et al. 1988, 257; Sherratt 2000, 87.

[30] Bass 1967; Sherratt 2000.

[31] Sherratt 2000, 87–8.

[32] Questions about the role of Cypriot copper in Mycenaean metallurgy represent a long-standing issue. Based on lead isotope analyses of Mycenaean bronze items, Gale (1991, 231) concluded: "In LH IIIB times Mycenae itself does not seem to have been making many artefacts from Cypriot copper even though a few Cypriot copper oxhide ingots were reaching it."

[33] Sherratt 2000, 83, 87–8. For a discussion of European and/or Italian objects on Kos and in the Dodecanese, see Vitale et al. 2017, 244, 248–51.

[34] The Linear B tablet Oa 730 from Knossos records a substantial amount of copper (60 ingots or 1,562 kg of metal); see Dialismas 2001, 124; Michailidou 2001, 88. For a discussion about the production and consumption of metal on Crete and Cyprus during the LBA, see Muhly and Kassianidou 2012, 121–23, 129–34. For a quantitative examination of metal consumption on LBA Crete, see Hakulin 2013.

[35] How Mycenaean palatial authorities acquired their copper

is notably more prevalent in the western Mediterranean—Sicily and Sardinia—than on the Greek mainland during the Late Helladic (LH) IIIB period (13th century B.C.E.).[36] The mainland's distribution of copper oxhide ingots or fragments thereof is limited to Mycenae, Thebes, and nearby islands—Kea (Ayia Irini), Salamis (Kanakia), and Euboea (Kyme).[37] The general rarity of Mycenaean metallurgical workshops, in contrast to the well-documented metalworking areas on Crete and Cyprus, is perplexing given the mainland's spike in bronze objects, particularly tools and weapons, from the Middle Bronze Age (MBA) to the LBA.[38] Despite this increase in metal consumption, a copper shortage for the late 13th-century Greek mainland, or at least the threat of such a situation as perceived by the Mycenaean palaces, is a distinct possibility, judging by the Pylian Linear B tablets. Furthermore, the paucity of Cypriot oxhide ingots on the Greek mainland as compared with the western Mediterranean is hard to explain given local copper sources on Sardinia and the ubiquity of bronze objects in the Mycenaean world. Perhaps new copper exchange routes excluded mainlanders (wholly or partially) from the customary LBA networks. Deliberate breaks in LBA trade patterns did occur elsewhere, such as an embargo against the Assyrians devised by the Hittite king Tudhaliya IV (1237–1209 B.C.E.). He ordered Shaushgamuwa of Amurru (in the northern Levant) to prevent Ahhiyawans (Mycenaeans) from trading with Assyrian merchants in his kingdom.[39] Changes, such as this one, to trade networks reflect localized phenomena. Evidence for a Mycenaean decline in metal might indicate a local disruption in Aegean trade that did not coincide with a Mediterranean-wide bronze shortage.

Tablets from Pylos suggest that the late 13th-century Palace of Nestor gave small portions of metal to individuals who provided the palace with finished products in return—precisely what those objects were is unclear.[40] This centralized distribution of metal to smiths within Messenia represents the Mycenaean *ta-ra-si-ja,* or allotment system, attested in other palatial centers for different raw materials.[41] Unfortunately, the frequency of these allocations is unknown.[42] Regardless of the rate of metal disbursement, there was undoubtedly an interest by palatial authorities in controlling the distribution of even small quantities of metal. But why? Does the Palace of Nestor's concern in tracking and dispensing copper and/or bronze reflect, as Chadwick first surmised, a shortage of metal in Messenia when scribes produced these tablets at the end of the 13th century B.C.E.?[43]

A more nuanced understanding of *ta-ra-si-ja* work has led Aegean scholarship to shift from envisioning the Mycenaean economy as a comprehensive top-down model based on a palatial redistributive center to seeing it as a system of mobilization.[44] Nosch, for

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is unknown. Brysbaert and Vetters (2015, 163) observed: "The terms of metal acquisition by the Mycenaean palaces remain elusive, because any hints to international trade are missing in epigraphic sources."

[36] Gale 1991; Lo Schiavo et al. 2009.

[37] Based on his interpretation of *ka-ko* as representing copper in the Pylian records, Muhly (1992, 18–19) argued that Pylos did receive oxhide ingots in the late 13th century B.C.E. See also Mangou and Ioannou 2000, 207–8; Muhly 2009, 17.

[38] Iakovidis 1982; Catling and Catling 1984; Hakulin 2004; Kayafa 2008; Blackwell 2011, 64–6, 116; Muhly and Kassianidou 2012. Despite the scarcity of Mycenaean metallurgical workshops, solid metallurgical evidence has emerged in the Lower Citadel at Tiryns; see Brysbaert and Vetters 2015; Rahmstorf 2015, 144–47.

[39] Collins 2007, 68. The Hittite term "Ahhiyawa" is much debated, though scholarly consensus connects the name to the Mycenaeans. More contentious is the locality of Ahhiyawa, though the Greek mainland remains a popular interpretation. See Beckman et al. 2011, 1–6, 267–83.

[40] Del Freo (2005) proposed that tablet PY Jn 829 testifies to the expectation that finished goods, namely spearheads and javelin points, will be brought to the palace as part of a *ta-ra-si-ja* arrangement.

[41] Smith 1992–1993, 179; Killen 2001; Nosch 2006. Cf. Gillis (1997, 511), who proposed a radically different understanding for *ta-ra-si-ja* metal: "Instead of the palace allotting raw materials, it is calling in finished products. The transactions are demands for finished products, 'obligations due,' rather than disbursements. Instead of the palace controlling metallurgy, it controls the finished products."

[42] Smith 1992–1993, 181; Killen 2001, 173; Shelmerdine 2008, 143. Cf. Nosch (2006, 172), who suspected that the *ta-ra-si-ja* system was annual, based on the recording of debts on tablet So(2) 4442.

[43] Chadwick 1976, 140–41; Muhly 1980, 44.

[44] Dickinson 2006, 37–8; Nakassis 2013a, 237–39; Parkinson et al. 2013. Cf. Killen (2008, 174–75), who observed: "While we do have evidence to suggest that the palaces did not have a direct involvement in such relatively simple forms of 'industrial' productions as net-making, coarse ware pottery production and the making of obsidian blades, it is difficult to believe that they did not control all 'industrial' production in the kingdoms that involved a high degree of craft specialization." I agree with Killen that the degree of a state's involvement in craft production depends upon the technological sophistication of the work. Regarding metallurgy, it is unlikely that Mycenaean

instance, demonstrated that parts of central Crete participated in Knossian *ta-ra-si-ja* textile work while others did not.[45] She also argued that the Knossian oversight of the textile industry involved two administrative systems and that certain Mycenaean cloths were not produced as part of *ta-ra-si-ja* obligations.[46] *Ta-ra-si-ja* arrangements may thus have entailed only part-time work, and the system did not necessarily encapsulate the administration of an entire craft industry. Messenian metallurgy was also varied; smiths not only obtained metal directly from the palace but also relied upon independent ventures and craft exchanges.[47] As Smith summarizes: "The small size of the [metal] allotments suggests that workers probably did a service for the palace through the *ta-ra-si-ja* service in addition to working their crafts for customers other than the palace."[48] Archaeological evidence attests to low-scale metallurgical production—probably decentralized activity unrelated to the Palace of Nestor—at Nichoria and perhaps at Katsimigas near Iklania.[49] The varied LBA palatial economy may have included local opportunities for metal exchange, whether at or near Mycenaean palaces or at secondary sites. The Gelidonya scrap metal and the emergence of a koine of bronze objects throughout the Mediterranean have led to the notion of freelance smiths who traveled about offering their services and selling goods.[50] The Pylian smiths mentioned in the Linear B tablets, however, relied to some extent upon a partially centralized, and probably deteriorating, metallurgical economy.

The Jn and Ja tablets reference as many as 263 named individuals as smiths (*ka-ke-we*), though the workforce also included unnamed slaves and may have totaled 400 individuals altogether.[51] The Linear B texts highlight three categories related to smiths: individuals with allotments of copper or bronze from the palace (*ta-ra-si-ja*); individuals (one-third of the named smiths) without a portion of metal (*a-ta-ra-si-jo*); and officials called *qa-si-re-we* (singular *qa-si-re-u*) who seemingly oversaw metal disbursements in the *ta-ra-si-ja* system.[52] Scholars have explored the evolution and substantial change in sociopolitical status from the Linear B term *qa-si-re-u* (*g*^{w}*asileus*) to the Homeric and historical Greek word βασιλεύς.[53] While the latter word refers to a king, the *qa-si-re-we* represent supervisors in the palatial system who oversaw smiths. The *qa-si-re-we* monitored some aspect of metal production, and Smith interpreted the occurrence of the word on tablets Jn 431, 601, and 845 as indicating "one *qa-si-re-u* in charge of overseeing the allotments" to craftspeople in the Hither province of the Pylian territory.[54] It is uncertain if *qa-si-re-we* resided at the palace or in the hinterland, but, as Shelmerdine has noted, "these officials really derived their power from local communities, one part of a nonpalatial hierarchy partly assimilated and used by the central administration."[55] Uchitel thus argued for the distribution of bronze from palace to village, with the latter dividing the material among local artisans.[56] Regardless of the locality of residence for the *qa-si-re-we,* they likely gave allotments to individuals rather than workshops, to judge by the meager weights.[57] The allotments in the Jn series are, on average, 3.5 kg, though some are as large as 12 kg.[58] Since a typical LBA copper oxhide ingot weighs approximately 28–29 kg, the average Pylian metal allotment represents 12.5% of a complete ingot.[59] The lowest allotment (e.g., M1 N1 or 1.56 kg) of metal would permit a smith to work for a few days and produce a small vessel, five daggers, or 1,000 arrowheads.[60]

If the palace dispersed allocations infrequently, the scanty metal allotments in the Jn and Ja tablets seem to portray a dire picture for smiths, even if they obtained

palaces controlled production entirely, but they probably had some oversight of the industry.

[45] Nosch 1997–2000, 28–37.

[46] Nosch 1997–2000, 43.

[47] Michailidou 2001, 87–9; Shelmerdine 2008, 143; Montecchi 2012, 187; Nakassis 2013a, 243.

[48] Smith 1992–1993, 179–80.

[49] Cosmopoulos 2006, 221; Aprile 2013, 434–35.

[50] Bass 1967; Gillis 1997, 512–13; Sherratt 2000, 85.

[51] Chadwick (1976, 140–41) stated that closer to 400 smiths may represent the true metallurgical workforce at this time. Nosch (2006, 163) makes an important distinction about the unnamed slaves: "*ta-ra-si-ja* smiths are not slaves—slaves are recorded on the same tablet but in a separate category. Some of the *ta-ra-si-ja* smiths have slaves." See also Nakassis 2013b, 73.

[52] Uchitel 1990–1991, 196–98; Smith 1992–1993; Nakassis 2013b, 74.

[53] Iacovou 2006; Shelmerdine 2008, 135; Nakassis 2013b, 13.

[54] Smith 1992–1993, 191; Nosch 2006, 168.

[55] Shelmerdine 2008, 135.

[56] Uchitel 1990–1991, 199.

[57] Nakassis 2013b, 79.

[58] Nosch 2006, 173; Shelmerdine 2008, 143; Nakassis 2013b, 79.

[59] Gale 1989, 247; Knapp 2008, 310.

[60] Michailidou 2001, 92–3; 2008, 528; Montecchi 2012, 186.

additional metal on their own.[61] Smiths received small allotments or nothing at all, though one might expect that an *a-ta-ra-si-jo* smith would get an allocation at a later time. Moreover, metalworking in late 13th-century Messenia was likely seasonal, with individuals supplementing that craftwork through other means such as herding and perhaps farming.[62] The names of several smiths reoccur in the Pylian records, indicating a hierarchy of workers with diverse skill sets, though the status of the *a-ta-ra-si-jo* smiths within this structure is unclear.[63] Nakassis pointed out that "smiths are sometimes involved in multiple activities in different places within the kingdom" and so may have been "generally involved in a variety of economic pursuits in different parts of Messenia."[64] One task that smiths undertook was palatial herding; Nakassis identified as many as 27 individuals in the Pylian tablets who were smiths and herders.[65] An individual named Plouteus (*po-ro-u-te-u*) possessed diverse abilities and a higher status, as indicated by his management of a metal allotment, 90 sheep, and 20 goats in various areas of the kingdom.[66]

Although Pylian smiths seem to have supplemented their metalworking for the palace through other economic activities, the prospect of a bronze shortage on the Greek mainland remains plausible at the very end of the 13th century B.C.E. While craftspeople offered varied skills and services within the Pylian economy, the combination of meager metal allotments and a significant metallurgical labor force warrants explanation. The large number of smiths in the Jn and Ja tablets, some of whom did not receive any allotment of metal, is striking. Why did so many Messenian smiths learn the craft of metallurgy when the metal allotments were small or nonexistent? The overly numerous metallurgical workforce in the Pylian kingdom implies that the scanty amount of metal may have been a recent phenomenon.[67] Dialismas argued that the Pylian Jn series is a more or less complete record of metal distribution by the palace, meaning there was a limited amount of bronze for distribution just before the palace's destruction.[68] To gauge by the number of people trained in this craft, the supply of bronze would seem to have declined in less than the span of a generation. The substantial concern with small amounts of copper and/or bronze at Pylos likely reflects a reaction to a changing economic environment.

The Pylian metallurgical industry is undoubtedly more complicated than the narrow perspective offered by the Linear B records, especially because debate exists about the translation of specific Mycenaean words. The total quantity of metal (*ka-ko*) listed in the Jn series is 1,046 kg according to the totaling tablet Jn 749.[69] It is difficult to judge, however, if this quantity is significant or not because it is unclear if the *ka-ko* stock consisted of a mix of raw copper and recyclable bronze. Scholarship remains divided on the interpretation of the 140 (AES) ideogram and the Mycenaean word *ka-ko* as either copper or bronze. Zaccagnini and Muhly both understood the *ta-ra-si-ja* metal (e.g., *ka-ko*) to be copper in the form of oxhide ingots.[70] In her detailed study of the Jn tablets, Smith reached a different conclusion: "It is difficult to be certain whether it [the metal allotment] is in ingot form or the form of scrap metal. It could have been allotted or collected in different forms—including ingots, fractions of ingots, scraps, and finished objects, for metal is a highly recyclable substance."[71] Although Muhly has maintained his interpretation that the ideogram and *ka-ko* should be understood as copper, especially when an ingot is also referenced in the text (oxhide ingots in the archaeological record are never made of bronze), Linear B specialists have not readily adopted this translation.[72]

[61] In his still-useful assessment of Mycenaean metalwork (a comprehensive study on the subject remains lacking), Iakovidis (1982, 226) concluded: "The amount of copper and bronze available on the Mainland diminished considerably" by the end of the LBA.

[62] Iakovidis 1982, 226; Uchitel 1990–1991, 202; Gillis 1997, 512.

[63] Nakassis 2015, 592, 599.

[64] Nakassis 2013b, 80.

[65] Nakassis 2013b, 114–16.

[66] Nakassis 2013b, 348; 2015, 587. Cf. Killen (2001, 173), who notes that the large number of smiths in the Pylian kingdom "suggest that they were not persons of particularly elevated status."

[67] Iakovidis (1982, 226) interpreted the number of bronzesmiths as indicative of the fluid nature of palatial work. Knapp et al. (1988, 257) take a different view: "Such a large number of smiths must reflect the size and importance of the bronze industry, one that produced finished goods for local use as well as for export."

[68] Dialismas 2001, 123.

[69] Muhly 1992, 19; Nosch 2006, 163.

[70] Zaccagnini 1986, 415; Muhly 1992, 18.

[71] Smith 1992–1993, 173.

[72] Muhly 2009, 19. Cf. Shelmerdine (2008, 143 n. 8) and Melena (2014, 140), who identified the AES ideogram as

One of the Pylos tablets, Jn 829, mentions the palatial collection of a metal, *ka-ko na-wi-jo,* traditionally understood as temple bronze, intended for recycling and eventual transformation into weapons.[73] Muhly, however, argued that the Mycenaean words "have nothing to do with temple bronze" but instead represent "ship copper."[74] This hypothesis has not gained acceptance, and Palaima, in a 2015 discussion of Jn 829, referred to this metal as recycled or scrap bronze.[75] The difficulty in discerning the precise metal within the Linear B records may indicate that scribes called both copper and bronze *ka-ko.* In practice, a palatial allotment of metal might, as Smith suggested, include a combination of raw material, scrap, and complete items, especially if craftspeople received their allocations during a metal shortage.

Metal vessels provide an analogous picture of a deficient supply of metal. Matthäus observed a decline in such objects after the LH IIIA period (14th century B.C.E.).[76] At first, Mycenaean metal vessels occurred primarily in graves, but during the LH IIIB period they largely disappeared from that context and appeared only sporadically in hoards. The change reflects not only fluctuations in funerary preferences but also socioeconomic constrictions in workable metal. This decrease in metal vessels in the 13th century, combined with the Linear B tablets from Pylos and the scant evidence for Mycenaean metallurgical workshops, may represent the beginning of a metallurgical decline on the mainland. In the Postpalatial and EIA periods, bronze consumption conspicously dropped compared to Mycenaean contexts.[77]

On the whole, the evidence for restricted supplies of metal on the 13th-century mainland, particularly the Linear B records from Pylos, seems convincing. However, the existence of a genuine 13th-century metal shortage is not as important, for the purposes of this paper, as the evident attention paid by the Palace of Nestor to even small amounts of metal. Even if sufficient bronze existed, decreases in bulk copper, or the perceived threat of decreases, could have negatively affected Mycenaean metallurgy and led to the rationing of resources. Textual records describe such oversight at Pylos, and the makeup of certain Mycenaean hoards implies that other mainland centers exercised similar control. Recovered metal assemblages also indicate the kinds of items—raw material, scrap metal, and finished products—that palatial authorities distributed. It is interesting to note that tools are quite prominent in these assemblages, and they might represent portions of *ta-ra-si-ja* allotments.

MYCENAEAN CACHES IN LIGHT OF EUROPEAN AND CRETAN HOARDING PRACTICES

Hoarding has received much attention in European archaeology, as thousands of metal assemblages have come to light in prehistoric contexts, typically from rivers or swamps, throughout northern Europe. Notable collections appear in Scandinavia, Britain, Ireland, Germany, Hungary, Poland, northern Croatia, Bulgaria, Romania, and Slovenia.[78] Harding recognized the practice as one of the "most discussed, though least understood, aspects of the Bronze Age," and Bradley has remarked that "it still remains uncertain why so much metal was buried and not recovered."[79] Taking context, if known, and overall composition into account, scholars have sought to assign a specific functionality, such as personal, merchant, scrap, or foundry hoards, to each assemblage.[80] Discussions of Aegean hoarding have borrowed terminology from European scholarship with two broad classifications: utilitarian and nonutilitarian.[81] The first is nonceremonial and considered recoverable in antiquity, while the latter category is ritualistic and nonretrievable after deposition (e.g., votive and foundation deposits).[82] Utilitarian types include personal, craftsperson (e.g., carpenter), merchant, and foundry caches and consist of tools

bronze rather than copper. For overview discussions about the interpretation of *ka-ko* and the AES ideogram, see Gillis 1997, 506–9; Michailidou 2008, 521–29.

[73] Ventris and Chadwick 1973, 511–14. Cf. Del Freo 2005.

[74] Muhly 1992, 18.

[75] Palaima 2015, 632–33. See also Murray (2017, 173), who notes that in the Mycenaean Postpalatial period—soon after the Jn and Ja series were written—there is "no archaeological evidence for ingots or slags, suggesting that remelting may have been one of the only ways to produce new bronze objects."

[76] Matthäus 1980, 340–42.

[77] Murray 2017, 162. For a detailed overview of bronze objects and their distribution, see Murray 2017, 165–82.

[78] Bradley 1990; Taylor 1993; Hänsel and Hänsel 1997, 101–232; Chapman 2000, 101–21; Harding 2000, 352–68; Bradley 2013; Wiseman 2018.

[79] Harding 2000, 352, 365; Bradley 2013, 128.

[80] Bradley 2013, 122–24.

[81] Knapp et al. 1988, 233–38; Borgna 1995, 8–14.

[82] Knapp et al. 1988; Bradley 1990, 10–14; Wengrow 2011, 137–39; Wiseman 2018, 39.

and a plethora of other items such as weapons, vessels, weights, fragmentary copper ingots, and scrap metal. Most Aegean assemblages fall under this category, though scholarship remains divided on the issue.[83] Ritual, votive, and foundation deposits—all thought to be inaccessible—represent ceremonial assemblages that typically contain a coherent and well-preserved group of objects.[84] Such assemblages occur in nondomestic localities, such as rivers, and comprise a narrow range of objects.[85] Though rare in the Mediterranean, there are a few examples of nonutilitarian hoards from Cyprus and the Levant (e.g., Kition, Enkomi, and Ras Shamra, Ugarit).[86]

The question of repossession provides a fundamental distinction in hoarding behavior, but determining intention is difficult.[87] Even if the desire to reclaim an assemblage existed, memory loss might have hindered recovery.[88] Since the deduction of intent stems from our modern perception of recoverability, the simple dichotomy between retrievable, utilitarian hoards and irretrievable, ceremonial assemblages may need revision.[89] Needham challenged this binary division in his analysis of European caches; he emphasized that a hoard's functionality may be flexible or fluid once the hoard is deposited, and it then becomes difficult to distinguish between utilitarian and ceremonial assemblages.[90] This key observation impacts the analysis of Mycenaean hoards described here. By assigning overarching utilitarian or nonutilitarian interpretations to caches, scholars may fail to recognize structural principles in a specific hoard's formation.[91] In other words, a focus on the character of the whole assemblage can obscure a more nuanced picture offered by looking at subsets of the hoard. Harding emphasized this point: "It is likely that no single explanation [of a hoard] will account for more than a proportion of the finds."[92] He recognized internal diversity in hoards, the flaw of simplified interpretations, and how individual European caches provide evidence for deliberate structure.[93]

The number and size of Aegean hoards fall dramatically short of their European counterparts. Harding thus envisioned Greece, with its "extraordinarily low representation of metal deposition," as a region relatively unaffected by hoarding tendencies and a "startling mismatch" for a palatial society with a developed metallurgical industry.[94] Despite Harding's assertion, hoards represent a substantial context for metal objects in Bronze Age Greece. There are at least 32 extant second-millennium metal hoards from Crete and 22 from mainland Greece (see fig. 1), in addition to a handful of EBA carpentry caches.[95] They turn up in palatial citadels, storage areas, wells, domestic settings, foundation deposits, and as stray finds. The online appendix associated with this paper lists the second-millennium Aegean hoards, their components, and relevant bibliography. This list is comprehensive but not exhaustive; it excludes treasures of precious metals, such as silver and gold, which reflect a different phenomenon related to luxury or prestige activities.[96] Also omitted from this data set is a metal assemblage from Arkalochori, Crete.

The exact nature of the impressive collection of bronze items from Arkalochori in central Crete near Galatas is vague because of contextual questions stemming from its discovery by local inhabitants in 1912. Subsequently excavated by Josif Hatzidakis, Arkalochori is traditionally understood as a Bronze Age sacred cave whose Neopalatial votive dedications indicate the height of activity at the site.[97] Questions exist, however, about whether the large fissure in the ground that yielded the objects was a cave and whether

[83] Knapp et al. 1988, 235–37. For a viewpoint that interprets several Mycenaean hoards as ritual foundation deposits, see Borgna 1995, 12, 40–3.

[84] Ellis 1968; Bradley 1990, 14.

[85] Harding 2000, 352–68.

[86] For ritual hoards in the eastern Mediterranean, see Schaeffer 1956, 251–75; Knapp et al. 1988, 243, table 3, 248–54. Cf. Matthäus and Schumacher-Matthäus (1986), who interpret all Cypriot LBA hoards as cultic in nature.

[87] Knapp et al. 1988, 241.

[88] Bradley 1990, 17–20.

[89] Dietrich 2014, 468–69.

[90] Needham 2001, 275.

[91] Chapman 2000, 46.

[92] Knapp et al. 1988, 240; Harding 2000, 352.

[93] Harding 2000, 354, 368.

[94] Harding 2000, 365. Cf. Borgna 1995, 7.

[95] For EBA hoards, see Branigan 1969; Fitton and La Niece 1989.

[96] Laffineur 2006, 37–8. The online appendix also excludes bronzes that may be grouped together in a museum but lack a verified common context. Two double axes and a sword from Kalopsana Metaxadha (Messenia) in the Chora Museum, for instance, do not represent a credible cache since the items were chance finds turned over to the museum at different times; see McDonald and Hope Simpson 1969, 147.

[97] Hatzidakis 1912–1913; Nilsson 1950, 60–1; Evely 2007; Flouda 2015, 45–7.

cultic activity indeed occurred at the site.[98] The quantity of the Arkalochori objects is unparalleled in the Aegean; the collection "was estimated to contain hundreds of bronze [nonfunctional] double axes, some of immense size, hundreds of knives or daggers, and dozens of swords. Some small silver and gold double axes were also discovered."[99] Preliminary publications have not reported the total number of items; furthermore, the recovered objects represent only a portion of the original deposition, since local people removed substantial quantities of metal from the site before excavation.[100] The reason for omitting the Arkalochori assemblage from the present analysis is multifold. Quantification of the collection is not precise, and it differs greatly from typical Aegean metal hoards. The Arkalochori metals probably indicate long-term social and/or religious practices by multiple (though not necessarily successive) generations. Based on the varied findspots and the broad chronological range of the objects, Flouda understood the assemblage to have formed through repeated episodes of deposition.[101] Because of its massive size and the likelihood of recurrent depositions over an extended period—regardless of whether they are cultic or not—the Arkalochori metal collection bears a closer resemblance to the massive European hoards than the second-millennium Aegean caches.

Minoan Versus Mycenaean Hoarding

A macro-view of Aegean stockpiling is needed to contextualize the components of Greek mainland caches and changes in hoarding behavior. Preference for tools in hoards began during the third millennium B.C.E. EBA collections lacked scrap metal and contained fewer than ten objects on average; most had three or more forms of wood- or stoneworking implements, namely axes, adzes, and chisels.[102] A broader range of tools, implement subtypes, weapons, vessels, raw material (ingots or fragments), and scrap metal characterizes the MBA–LBA Aegean hoards (see online appx.). Numerous assemblages appear to be material intended for melting and recasting. Rarely, however, does a hoard's context signify the locality of a metallurgical workshop.[103] Although Aegean assemblages contained raw or scrap material for working, other elements such as furnaces, tuyeres, crucibles, tongs, charcoal shovels, furnace sticks, sledgehammers, and molds are absent.[104] Cold metalworking tools such as whetstones, files, and anvils do appear in specific assemblages, yet the overwhelming majority of hoarded implements are wood- or stoneworking types (e.g., axes, adzes, chisels, drills, saws) and utilitarian implements such as knives.

Most Cretan hoards date to the Neopalatial period, but examples appear in the transitional Early Minoan (EM)–Middle Minoan (MM) period, the Protopalatial era (MM IB–MM II), and the Late Minoan (LM) IIIC phase (see fig. 1; online appx.). Cretan hoards have turned up in numerous settings, from centralized palaces (e.g., Zakros, Mallia, Knossos, and Phaistos) to smaller settlements (e.g., Mochlos and Karphi) to unexpected stray finds (e.g., Avgo and Rotasi). Though more hoards exist from Crete (32) than the mainland (22), the latter assemblages are significantly larger (table 1; fig. 2; see online appx.). Minoan caches, averaging 11.3 objects, are barely bigger than the EBA Aegean assemblages and never greater than 40 items. In contrast to the presumed economic environment that influenced several Mycenaean caches at the end of the LBA, a metal crisis did not affect the formation of Minoan hoards, most of which correspond to a flourishing Neopalatial metallurgical industry.[105]

Implements represent more than half of the objects in Cretan assemblages while weapons are quite rare (see table 1; fig. 2). Metal vessels, raw material, and miscellaneous materials appear, but not in overwhelming numbers. Functional double axes, saws, and broad chisels (with a cutting edge greater than 3.0 cm)—

[98] P. Muhly (1981, 367) argued that the "cultic use of the cave is dubious" and that the "extraordinary character of the finds" make the unusual site "unsuitable for any sustained activity, let alone as an important cult center."

[99] Evely 2007, 177.

[100] Hatzidakis 1912–1913; Nilsson 1950, 60.

[101] Flouda 2015, 52. Cf. P. Muhly (1981, 367), who does not find evidence for long-term activity at the site.

[102] Branigan 1969; Fitton and La Niece 1989.

[103] Borgna 1995, 12, 21, 26. One example of a hoard found within a workshop comes from Mochlos' artisan quarter, dated to LM IB; see Soles 2003, 20, 23, fig. 17, pl. 12d. As discussed below, the remains of a metallurgical workshop, the Unexplored Mansion at Knossos, bear a resemblance to some Cretan hoards; see Catling and Catling 1984.

[104] Such metallurgical implements are more common in Cypriot hoards; see Catling 1964, 278–91; Knapp et al. 1988, 242, table 2, 254; Borgna 1995, 23–6.

[105] For a summary of Minoan metal workshops, see Hakulin 2004.

TABLE 1. Quantitative overview of objects in Cretan and mainland hoards.

	Hoards	Total Objects	Tools	Weapons	Metal Vessels	Raw/Scrap Metal	Miscellaneous Items
Crete	32	362+	199	20	45	34+	64+
Mainland	22	592	298	104	40	78+	72+

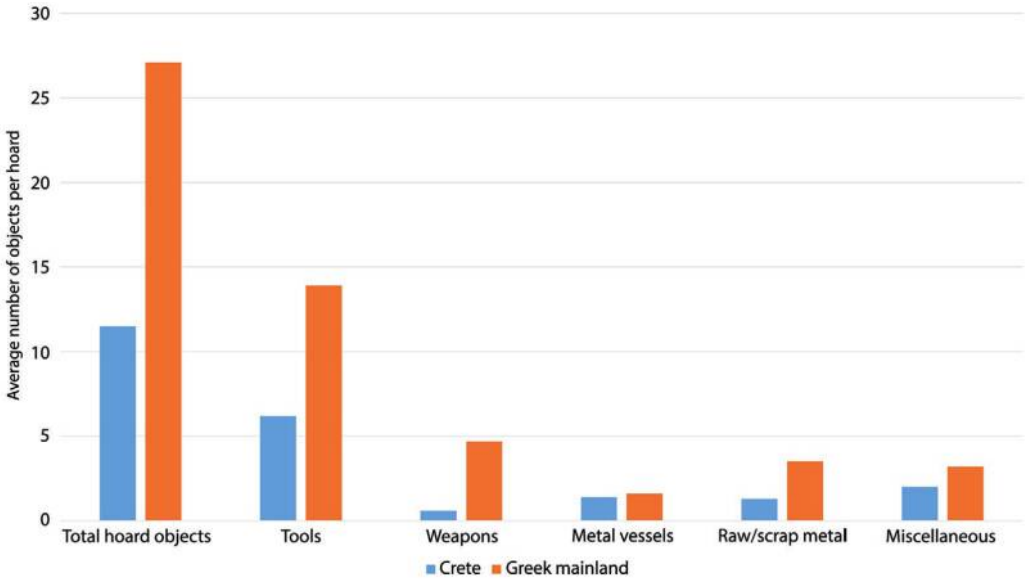

FIG. 2. Average number of objects in Cretan and mainland hoards.

often referred to as "ogival"—are favored implements in Cretan caches.[106] So are specialized tools—double-ended implements such as axe-adzes, double adzes, pick-adzes, and axe-hammers—that are scarce on the mainland (fig. 3).[107] Agricultural (e.g., sickles, picks, and shovels) and metallurgical tools (e.g., hammers, tongs, whetstones, anvils, and ingot breakers) are absent from early second-millennium Cretan hoards and infrequent by the LBA. Materials within Cretan hoards resemble the objects from the LM II metal workshop in the Unexplored Mansion at Knossos; tools (both complete and fragmentary examples) from that context included knives, saws, double-axes, chisels, drills, and awls.[108] Though the Unexplored Mansion's metal finds testify to a metallurgical workshop, the location of that pyrotechnological activity is uncertain. This context thus might reflect storage space rather than actual metalworking.[109] It is difficult to reconstruct or categorize the Unexplored Mansion's metal objects as discernable hoards, but it is worth noting that the workshop may have contained several scrap assemblages comparable to caches found elsewhere on Crete.

Two Protopalatial hoards from Quartier Mu (Mallia) constitute credible carpenter and/or mason tool kits (see online appx.). The first, from Building A (room I9), contained an axe-adze, saw, drill, and knife. The second, from Building B (room IV4), had a double axe, saw, socketed adze, and mortise chisel. Poursat recognized both hoards as carpentry sets based on the inclusion of single examples of different tools and the omission of nontools.[110] Although Mycenaean hoards are more complicated than the Quartier Mu sets, the

[106] Evely 1993.
[107] Blackwell 2011, 166–77.
[108] Catling and Catling 1984, 213–15.
[109] Muhly and Kassianidou 2012, 121.
[110] Poursat 1985.

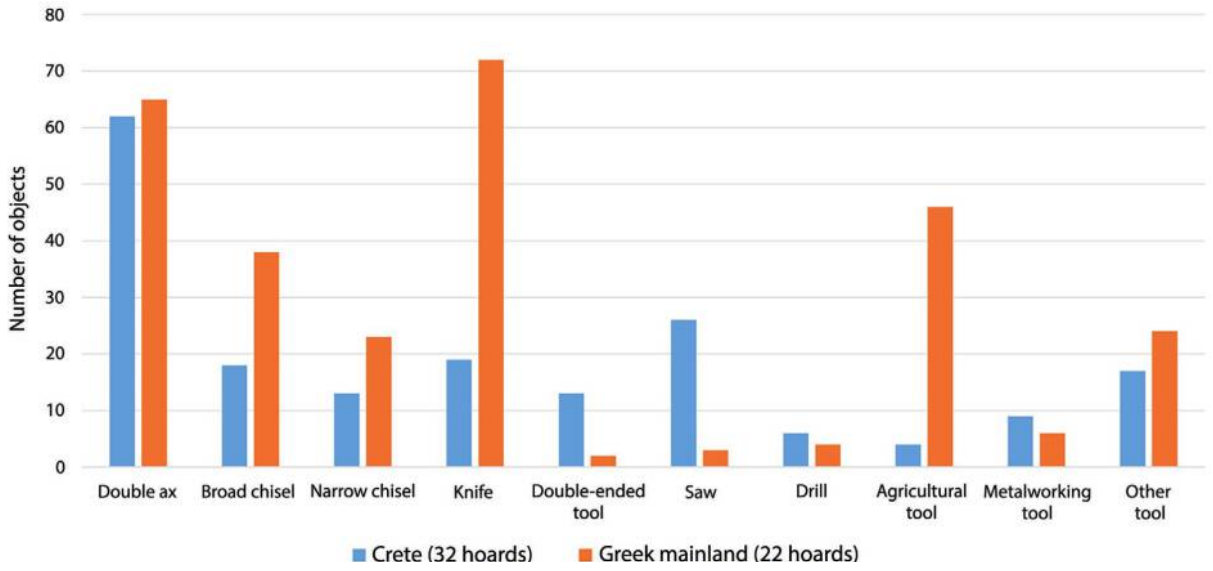

FIG. 3. Number of tool types in Cretan and mainland hoards.

latter demonstrate how implement variation may aid in the identification of a tool kit.

Metal assemblages from the mainland and its immediate realm of influence (e.g., islands such as Euboea, Salamis, and Aegina) occur throughout the second millennium B.C.E. yet cluster at the end of the LBA (see fig. 1; online appx.). Only two hoards—from Lerna and Malthi—come from Middle Helladic (MH) contexts, while one, the Andronianoi assemblage from Euboea, dates to LH II–IIIA1 at the end of the Early Mycenaean era.[111] Scholars assign most mainland hoards to LH IIIB, LH IIIC, or the transition between these phases—that is, between the end of the 13th and the beginning of the 12th century B.C.E.[112] Dating a hoard is notoriously difficult even if a cache's context is known, since the formation of an assemblage may differ temporally from its entrance into the archaeological record. The so-called Tiryns Treasure, for example, contained objects from several periods, but its deposit dates to LH IIIC.[113]

The Lerna and Malthi MH caches resemble the EBA and MM hoards in their size. By the LBA, mainland assemblages were more diverse and notably larger (see online appx.). This complexity distinguishes Mycenaean hoards from Minoan examples. With nearly 27 objects on average, mainland hoards are nearly two and a half times bigger than the typical Cretan caches (see table 1; fig. 2). The Athens Acropolis hoard illustrates a characteristic Mycenaean assemblage with its size (35 objects) and high frequency of tools (fig. 4).[114] The two largest Mycenaean assemblages—the Mycenae Tsountas and Orchomenos hoards—include roughly 100 objects each, more than double any Cretan collection.[115] Likewise, twice as many tools exist in Mycenaean hoards than in Minoan ones (see table 1; figs. 2, 3). Despite sharing a general preference for tools, Crete and the mainland differ in the implement types they hoarded (see fig. 3). The saws and double-ended tools (excluding double axes) in Cretan hoards are mostly absent on the mainland. Knives and sickles, however, are more prominent in mainland assemblages. Double axes remained popular in both regions, while chisels occur with greater regularity in mainland hoards. The Minoan and Mycenaean data sets also diverge with regard to weapons. Swords, daggers, spearheads, spear butts, and arrowheads are relatively common in Mycenaean assemblages but unusual on Crete.

[111] Valmin 1938, 102–3, 368–69; Caskey 1957, 151; Paschalidis 2007.

[112] Catling 1964; Spyropoulos 1972; Knapp et al. 1988.

[113] Maran 2006; 2012, 121–26.

[114] Catling 1964, 296; Borgna 1995, 22.

[115] Since the Tsountas hoard is large and its context uncertain, it may represent two assemblages combined into one when the materials arrived in the National Archaeological Museum of Athens. See Catling 1964, 294; Knapp et al. 1988, 246.

FIG. 4. A portion of the Athens Acropolis hoard: *left column, top to bottom,* dagger, knife, file, dirk casting, double hammer or anvil, axe-hammer; *second column from left,* seven broad chisels, one narrow chisel; *third column from left, top to bottom,* two plowshares, three double axes; *right column,* six double axes; hoard items not shown: double axe fragments, sickle, spearhead, bowl, and disks (© Acropolis Museum).

TOOL SETS AND SCRAP METAL IN MYCENAEAN HOARDS

Conceptualizations of foundry hoards assume a random assortment of metal items, yet the collation of such materials in some Mycenaean hoards is more deliberate than accidental.[116] Seven mainland hoards contain a distinctive selection of tool types that implies a structured rather than a haphazard formation. Caches from Mycenae (Mylonas, Poros Wall, and Tsountas hoards), Athens, Thebes, Orchomenos, and Anthedon include the same selection, though the quantity of each implement varies from assemblage to assemblage (see online appx.). This set consists of a double axe, a chisel with a broad cutting edge (3 cm or more), a chisel with a narrow cutting edge (less than 3 cm), a single-edged knife, and a sickle (table 2). Moreover, the Kalydon-Psorolithi hoard, found at the edge of a field near a stream 2.5 km from the site, lacks only the narrow chisel to have the full set.[117] Each of these hoarded tool types includes a range of lengths and widths. The general tool shape thus recurs from hoard to hoard, but individual examples are not necessarily exact copies. Take, for instance, the double axes; the length of double axes in Mycenaean hoards ranges from 13.0 cm to 22.5 cm with an average length of 19.25 cm.[118] Similarly, the width of a double axe's cutting edge varies from 4.9 cm to 7.5 cm, and the average width is 5.9 cm. The coexistence in the Mycenaean hoards of two chisel sizes (with a 3.0 cm wide cutting edge providing a distinct division) indicates functional variability, a hallmark trait of a tool kit.[119] The Anthedon hoard lacks a broad chisel, but its lugged adze/chisel had a cutting edge (4.2 cm wide) that could have been a substitute for a wide chisel. Both knives and sickles are consistent in their basic form in the Mycenaean hoards though variation occurs in their overall lengths. The inclusion of these objects reflects Mycenaean tool preferences, since knives and sickles are substantially more common on the mainland than on Crete. The hoarded sickles are especially notable because metal agricultural tools are otherwise rare in Aegean contexts.[120]

As a survey of the distribution and quantity of metal tools from Mycenaean contexts shows, the frequency and availability of these five hoarded implements vary

[116] Borgna (1995, 32) observed repetitive object choices in certain Mycenaean hoards, citing it as evidence for intentional accumulation.

[117] Mastrokostas 1965.

[118] Personal measurements of hoard tools; for a general discussion of double axes and size variation, see Blackwell 2011, 138–45.

[119] For an overview of different chisel sizes in the Aegean, see Blackwell 2011, 157–64.

[120] The lack of Minoan metal agricultural implements is surprising, and the category does not appear in Evely's (1993) seminal work on Minoan tools.

TABLE 2. Tool selections in mainland hoards. Gray shading indicates assemblages with repeated tool types (double axe, broad chisel, narrow chisel, knife, and sickle).

Hoard	Double Axe	Broad Chisel	Narrow Chisel	Knife	Double-Ended Tool	Saw	Drill	Agricultural	Metal Working	Other
Lerna	–	✓	–	–	–	–	–	–	–	–
Malthi	–	–	✓	✓	–	–	–	–	–	–
Andronianoi Euboea	✓	–	–	–	–	✓	–	–	–	razor
Ayios Vasileios	–	–	–	✓	–	–	–	–	–	–
Mycenae Poros	✓	✓	✓	✓	–	–	✓	sickle	hammer	cleaver
Mycenae Mylonas	✓	✓	✓	✓	–	–	–	sickle	–	awl
Mycenae Schliemann	✓	–	–	✓	–	–	–	–	–	–
Mycenae Tsountas	✓	✓	✓	✓	–	–	–	sickle	–	awl, cleaver
Athens Acropolis	✓	✓	✓	✓	double hammer, axe hammer	–	–	sickle, plowshare	anvil, file?	–
Thebes Arsenal	✓	✓	✓	✓	–	–	–	sickle	anvil?	pestle?
Orchomenos	✓	✓	✓	✓	–	✓	✓	sickle		
Kalydon	✓	✓	–	✓	–	–	–	sickle	–	–
Katamachi	✓	–	✓	–	–	–	–	–	anvil	–
Ithaka Polis	–	✓	✓	✓	–	–	–	–	–	–
Aegina Oros	–	–	✓	✓	–	–	✓	sickle	–	razors
Tiryns treasure	–	–	–	–	–	–	–	sickle	–	–
Salamis Kanakia	–	✓	✓	–	–	–	–	sickle	–	–
Anthedon	✓	adze/ chisel	✓	✓	–	–	–	sickle, plowshare	–	awl
Kierion Karditsa	✓	✓	–	–	–	–	–	–	–	–
Stephani	✓	–	–	–	–	–	–	whetstone	–	–
Rodotopi	–	–	–	–	–	–	–	–	–	shaft-hole axe

greatly (table 3).[121] The majority of Mycenaean double axes, broad chisels, and sickles on the mainland come from hoards. In contrast to this pattern, narrow chisels and knives are more often found in contexts outside of hoards. Table 3 also illustrates that, out of all 20 LBA hoards from the mainland and nearby islands, the seven assemblages with the repeated tool grouping contain most of the hoarded examples of these five tool types. These data raise questions about how freely some types of metal tools circulated among craftspeople and laborers. The general restriction of certain implements to hoards also suggests that greater value was attached to specific tool types than has previously been understood. Although tools are the most common object in second-millennium Aegean hoards, no other pattern in hoard contents is as distinctive as this one in the 54 Cretan and mainland hoards considered here (see online appx.).

A coherent explanation for the repeated grouping of oddly matched tools is not immediately apparent.

[121] The data in table 3 are based on Blackwell 2011, which includes a large data set of second-millennium tools from the Aegean and eastern Mediterranean; see esp. Blackwell 2011, 115–25, 199–201, 214–16.

TABLE 3. Quantities of tool group components from the LBA mainland.

Tool Type	Total LBA Mainland Examples	Examples from All Mycenaean Hoards (% of Total LBA Mainland Examples)	Examples from Mycenaean Hoards with the Repetitive Tool Set (% of Examples from All Mycenaean Hoards)
Double axe	106	65 (61.3%)	41 (63.1%)
Broad chisel	44	35 (79.5%)	32 (91.4%)
Narrow chisel	75	19 (25.3%)	16 (84.2%)
Knife	386	75 (19.4%)	48 (64%)
Sickle	55	45 (81.8%)	35 (77.8%)

The double axes are traditionally considered woodcutting implements, yet experimental work with double axes has demonstrated the effectiveness of the tool on both stone and wood.[122] While carpenters did use chisels, especially elongated, thick, and narrow types for cutting mortises, masons routinely used chisels for shaping stone.[123] Knives represent an all-purpose tool for crafts, food processing, and everyday needs. The sickles resemble knives except with a more pronounced concave curve along the cutting edge; they are thus designed to facilitate the harvesting of grains. Metal farming tools are an LBA phenomenon; stone blades and wooden plowing implements had served agricultural and digging needs for millennia. This fact and the contextual distribution of Mycenaean metal agricultural tools primarily in hoards may mean that these metal implements were particularly valued; they are unnecessary, albeit useful, for successful farming, and their availability is limited.[124]

The purpose behind the mix of carpentry and masonry tools (double axes and chisels), a generally utilitarian tool (knife), and an agricultural tool (sickle) is puzzling, and the grouping must be considered multifunctional. One could perform varied work tasks with such a set, particularly on a farmstead. Whatever its intended purpose, the grouping of tools appears deliberate, to judge by its recurrence in different types of assemblages. Consider, for instance, the examples from Mycenae. The relatively small Mylonas hoard (20 objects; see online appx.) exhibits distinct implement diversity with four double axes, one broad chisel, one narrow chisel, two knives, three sickles, and two awls (fig. 5).[125] Among the numerous oxhide ingot fragments and broken or distorted objects in the larger Poros Wall hoard (80+ objects; see online appx.), a coherent, recognizable implement set exists: one double axe, one broad chisel, three narrow chisels of different sizes, one drill, three bent knives, six sickles, and one small hammer.[126] As one of the biggest caches, the Tsountas hoard (93-plus objects; see online appx.) consists overwhelmingly of implements and has been understood as an assemblage belonging to a merchant.[127] The variety and repetition of implements in the cache may reflect several tool kits, and the sheer quantity of items may signify state property rather than a personal or merchant collection. These three hoards from Mycenae differ in their size, state of preservation, and overall components, yet they are remarkably similar in the tool types represented.

Mainland assemblages include a mix of complete and damaged—sometimes quite broken—implements.[128] Fragmentary double axes, chisels, knives, and sickles appear alongside complete versions, yet the seven hoards with the repeated group of tools contain mostly unbroken examples of each component of the group. Exceptions include bent and fragmentary knives from the Poros Wall hoard and a damaged knife and sickle from the Athens hoard. Still, the general picture is of functional and unbroken implements in the hoarded tool sets. It is worth asking why this par-

[122] Lowe Fri 2011, 53–60.

[123] Blackwell 2014, 453–54. It should be noted, however, that mortise chisels are rare in Mycenaean hoards.

[124] Blackwell 2011, 72–87.

[125] Mylonas 1962, 406–8, pl. 121.

[126] Wace 1953.

[127] Catling 1964, 294; Spyropoulos 1972, 8–45; Knapp et al. 1988, 246. As already mentioned (supra n. 115), the Tsountas hoard may represent two different assemblages, though this is impossible to verify.

[128] Borgna 1995, 12–15.

FIG. 5. Tool group in the Mylonas hoard from Mycenae: *top,* four double axes; *bottom left,* broad chisel, narrow chisel, two awls; *bottom right,* two knives; tools not shown from the group: three sickles (courtesy Archaeological Museum of Mycenae).

ticular collection of tools repeatedly appears alongside scrap metal.

A basic tenet in the interpretation of hoards has been that the accumulation of metal—regardless of the objects' sizes, shapes, functions, or secondary value—was the primary factor behind an assemblage's formation.[129] The market for scrap in the 13th century B.C.E. seems to warrant this reasoning.[130] Bits of unrecognizable metal pieces, oxhide ingots, broken tools and weapons, and fragmentary vessels point to a foundry assemblage—a categorization applied to the Poros Wall (Mycenae), Athens, Orchomenos, and Anthedon hoards.[131] The caches have been viewed as collectives rather than as aggregates of different kinds of individual pieces; in an assemblage characterized as a foundry hoard, most of the hoard objects are understood as scrap. Traditional interpretations see broken implements as unusable, yet Chapman has argued that fragmentary utensils in European contexts need not have lost their functionality.[132] Likewise, Dietrich concluded that fragmentation in European hoards can reflect new meaning, extending an object's function beyond its original intention.[133] In the Aegean, incomplete tools in hoards often preserve a cutting edge, thereby retaining, possibly, some functional worth. Broken double axes, for instance, might serve as wedges and need not be scrap material for recycling. The Linear B records show the retention and value of special objects even when damaged. An inventory of metal vases in the Ta tablets at Pylos includes damaged tripods missing some or all of their legs. Given the luxury products on that list, it is likely that such tripods retained value as keepsakes rather than scrap material to be recycled.[134]

The Orchomenos cache consists of an assortment of fragmentary tools, weapons, vessel or stand fragments, scrap, and miscellaneous bronze pieces that seemingly illustrate an archetypal founder's hoard (see online appx.).[135] The assemblage, however, also has a well-preserved tool kit: a double axe, broad chisel, narrow chisel, single-edged knife, sickle (missing just its tip), and drill (fig. 6).[136] These are the only complete objects within an assemblage of 106 items, underscoring the significance of that tool group. Foundry assemblages, therefore, may not be entirely random assortments of recyclable metal. The content of collections, indeed, could reflect intentional selection that provided internal structure in the formation of an assemblage.[137] Orchomenos' well-preserved set of tools—similar to kits found elsewhere—is no coincidence, even if the rest of the assemblage represents miscellaneous scrap. A simple but important conclusion about assemblages with tool sets and recyclable scrap is that they are the result of both deliberate and random selection. Our understanding of foundry hoards must account for the possibility that the destination for some objects was the furnace while other pieces could remain in use. It

[129] Knapp et al. 1988, 237, 254.

[130] Knapp et al. 1988, 257; Sherratt 2000.

[131] Desborough 1964, 48; Spyropoulos 1972, 200–2; Knapp et al. 1988, 248, 254.

[132] Chapman 2000, 49–104.

[133] Dietrich 2014, 482.

[134] Palaima 2003, 198–99; 2004, 113–14.

[135] Spyropoulos 1970; 1972.

[136] Spyropoulos 1970.

[137] For a parallel of structured hoarding outside of the Aegean, see Dietrich (2014), who considers large hoards from the Carpathian Basin.

FIG. 6. Tool group from the Orchomenos hoard: *top to bottom,* broad chisel, narrow chisel, drill, double axe and knife; tool not shown from the set: sickle. Archaeological Museum of Chaironeia, inv. nos. 501, 511, 522, 523, 568 (courtesy Archaeological Museum of Chaironeia).

is doubtful that craftspeople intended to melt and recycle the serviceable Orchomenos tool kit along with the cache's numerous scrap fragments.

MYCENAEAN HOARDS AS PALATIAL STOCK AND AS METAL *TA-RA-SI-JA* ALLOTMENTS

Previous scholarship on the *ta-ra-si-ja* system has not explored whether remnants of metal allotments exist in the archaeological record, yet some Mycenaean hoards might fit the description. The repeated tool groups in assemblages from elite contexts might provide evidence of palatial control in the selection of specific items for inclusion in a hoard. Although the extent of administrative similarities among the Mycenaean centers is uncertain, the hoards from elite contexts seem to reflect the same prescribed group of tools that included relatively common as well as rarer tool types. This apparent standardization of the tool types could indicate that palatial authorities influenced implement groupings. Several Mycenaean hoards found within citadels could represent stock under the supervision of officials. The *qa-si-re-we* were involved in the supervision of the Pylian metal industry, and they seem to have interacted with local communities on a regular basis. Regardless of their place of residence, the *qa-si-re-we* would have visited the palatial grounds frequently. It is thus possible that palatial metal assemblages relate to the *qa-si-re-we* officials. Other assemblages, not found within a citadel but containing the repeated grouping of tools, seem to be connected to the citadel hoards. It appears likely, therefore, that two categories of state-owned hoards are detectable in the Mycenaean archaeological record. The first is a stock of palatial metal that could be added to or subtracted from, perhaps held for and monitored by the *qa-si-re-we.* Such stocks of material might represent objects intended for distribution as well as items returned to the center. The second category is a metal allotment from a *ta-ra-si-ja* arrangement.

The findspots of the hoards with the repeated tool groups provide strong evidence for palatial control of the contents. Only the Anthedon collection fails to come from a palatial or elite context. The Mycenae assemblages were found either within or nearby the citadel. The Mylonas hoard came from a niche in a retaining wall near the monumental staircase leading

to the megaron.[138] In the late 19th century, Tsountas discovered his massive hoard between walls near the Lion Gate, presumably within the citadel proper.[139] The Poros Wall hoard came from outside the citadel walls, beside a curved wall between the Aegisthus and Klytemnestra tholoi.[140] These three hoards from Mycenae date to the end of the LH IIIB period, thus contemporary with the Jn and Ja tablets that imply a shortage of metal in the kingdom of Pylos. The Athens Acropolis hoard turned up between Bronze Age walls deeply buried south of the Parthenon.[141] Iakovidis argued that someone deliberately hid the hoard objects between these fragmentary walls and the citadel's southern circuit wall, and he noted that the assemblage closely resembled the Mylonas cache.[142] Borgna interpreted the context differently, arguing that the hoard's deposition took place before the construction of the wall that concealed it.[143] The Ephorate of Antiquities of Boeotia found a LH III metal hoard in 2006 in the area of the Arsenal at Thebes, a space known for its collection of Mycenaean weapons and armor.[144] Symeonoglou considered the Arsenal beyond the limits of the Mycenaean palace, but the exact relationship of the two Theban structures remains uncertain.[145] The metal hoard from Orchomenos came from a well, clearly a secondary deposit. Orchomenos' palatial character, however, is evident from its impressive tholos tomb—the Treasury of Minyas is comparable in design, decoration, and execution to Mycenae's Treasury of Atreus—and the town's likely role in contributing to the 13th-century Kopaic drainage project.

Mycenaean remains at Anthedon include walls and surface pottery, yet the Anthedon assemblage came from a later context—a classical temple.[146] The assemblage dates to LH IIIC, but someone added to it and redeposited it during the Archaic or Classical period. It is intriguing to contemplate whether a relationship or metallurgical link existed between Anthedon and Mycenaean Thebes since both Boeotian sites have yielded bronze hoards. One of the Linear B finds from Pelopidou Street in Thebes provides tentative evidence that Thebans interacted with people from an area near Anthedon. Tablet Gp 127 records that the Theban palace gave wine to men called *i-si-wi-jo-i,* interpreted by Del Freo as an ethnic marker for individuals from Iswos, which might refer to Isos, the possible identification of a hill site located a few kilometers from Anthedon.[147]

In her analysis of Mycenaean hoards, Borgna highlighted notable patterns including hoard similarities and the palatial role in collecting metal. She interpreted several of the mainland hoards considered here as ritualistic foundation deposits that reflect a competitive, elite practice of deliberately removing usable metal objects from circulation as a display of wealth.[148] Borgna rejected the traditional notion that these assemblages were utilitarian and held that those responsible for their deposition did not intend to retrieve them. Here, it is crucial to recall Needham's warning about the difficulty of differentiating between utilitarian and nonutilitarian hoards, especially when contextual details are limited.[149] It is probably impossible to ascertain whether the depositors intended to recover these assemblages. The interpretation proposed here thus relies on the components of the individual hoards and does not try to determine whether or not they were meant to be retrieved.

The repeated tool set in the Mycenaean hoards is likely multifunctional and would be useful on a farm. In the context of the *ta-ra-si-ja* system, it is worth considering whether authorities may have distributed tools as part of an allotment. Perhaps the tools could facilitate the manufacture of the requested products in the *ta-ra-si-ja* obligation, though the hoarded tool sets are not metallurgical implements. Surely palatial authorities had expectations for the metal objects produced through *ta-ra-si-ja* work. How did the smiths receive their instructions? One possible scenario is for an

[138] Mylonas 1962, 406; Borgna 1995, 21.

[139] Catling 1964, 294–95; Borgna 1995, 19–21. Unfortunately, the precise location and context of the Tsountas cache are vague.

[140] Wace 1953, 7, fig. 1, pl. 2; Borgna 1995, 13.

[141] Iakovidis 2006, 175, fig. 284.

[142] Iakovidis 2006, 175.

[143] Borgna 1995, 19–20.

[144] I thank the Ephorate of Antiquities of Boeotia for allowing me to mention this unpublished find. Some of the hoard's contents are now on public display in the Archaeological Museum of Thebes. For general information about the Arsenal at Thebes, see Symeonoglou 1985, 229–31.

[145] The Arsenal is near the known portion of the Theban palace, but the extent of the Mycenaean palace at Thebes remains unclear. Cf. Symeonoglou 1985, 231.

[146] Rolfe 1890; Hope Simpson 1965, 128–29, no. 437.

[147] Del Freo 2009, 57–8.

[148] Borgna 1995, 19–21, 40–3.

[149] Needham 2001, 275.

allotment to consist of material for craftwork as well as still serviceable items that could be copied to fulfill a work order. Among the broken metal objects and scrap in the Orchomenos hoard are single, intact examples of the repeated tool set (plus a drill) that recurs in other assemblages (see fig. 6). Perhaps the Orchomenos tool set represented models for what authorities expected smiths to manufacture as *ta-ra-si-ja* work.[150] Physical examples of the objects to be produced could help smiths fashion stone or terracotta molds in which to cast close reproductions of the original item.

Another possibility is that the state distributed tools needed by laborers. Mesopotamian state authorities during the Ur III and Old Babylonian periods (late third and early second millennia B.C.E.) weighed, recorded, and even dispensed copper tools and objects.[151] Likewise, in the LBA, palatial authorities at Ugarit (Syria) distributed bronze equipment and tools to various farms in its territory.[152] In the Aegean, Knossian tablets include two ideograms—a saw (*72, Mycenaean *pi-ri-je*) and a device interpreted by Linear B specialists as large tongs or pincers for moving stones (*182)—that might be construction tools; it is uncertain, however, if the Cretan palace dispensed these implements to laborers.[153] Neither systematic recording of Mycenaean tools nor documentation of their allocation occurs in the Linear B texts, yet Palaima believes that indirect evidence might exist.[154]

Palaima proposed that tablet Jn 829 from Pylos might imply the distribution of work tools. The much discussed text records that palatial officials (called *ko-re-te-re* and *po-ro-ko-re-te-re*) received *ka-ko na-wi-jo* (usually understood as temple bronze) from each of the 16 Pylian districts; the tablet also mentions javelin and spear points, though interpretations differ on the meaning of the text.[155] The traditional interpretation sees the collection of temple bronze as a prelude to the recycling of bronze and subsequent production of weapons.[156] Del Freo, however, understood the *ka-ko na-wi-jo* as already-finished spearheads and javelin points brought to the palace as part of a tax, leading Michailidou to note that such a scenario might also represent the return stage of a *ta-ra-si-ja* arrangement.[157] Because the *ko-re-te-re* and *po-ro-ko-re-te-re* officials on the tablet seem to have interacted with local supervisors of agricultural activities (e.g., "fig supervisors" and "overseers of digging"), Palaima speculated that the *ka-ko na-wi-jo* might consist of scrap material from agricultural equipment. He argued that the *ko-re-te-re* and the *po-ro-ko-re-te-re* "have an authorized claim to what appears to be the scrap-metal bronze that comes from worn tools used in agriculture and from cult implements that are in disposable condition."[158] Regardless of the exact meaning of the Jn 829 tablet, it indisputably indicates that the Palace of Nestor monitored and collected certain metal objects from each of its districts,[159] and this fact has further implications. Palaima elaborated: "Following this transaction [collection of bronze items from each area] in reverse, we might posit reasonably that the palatial center could lay claim to these objects because they [*ko-re-te-re* and *po-ro-ko-re-te-re*] had been responsible for their distribution or donation in the first place."[160] This hypothesis raises the prospect that the Pylian palace distributed functional work tools as well as raw materials.

Traces of wood or fibers reportedly were found in the Athens cache, which led Borgna to speculate that the items in this hoard included whole objects—presumably with organic handles—rather than just bronze pieces.[161] This tantalizing detail suggests that some objects were deposited in caches for their functional utility rather than only for their metallic value. The distribution of tools by palace authorities might explain the repeated implement grouping in these Mycenaean hoards, and the findspot of the Athenian hoard inside the Mycenaean citadel would support its identification as state property.

Hoards as Palatial Stock

Several Mycenaean hoards found within citadels might represent stock belonging to or retained for metal supervisors such as the *qa-si-re-we* in the Pylian records. Examples include assemblages from Athens,

[150] Borgna (1995, 27) mentioned the possibility of items representing workshop models when discussing the function of the weapon castings in the Athens and Tsountas hoards.

[151] Postgate 1992, 225–28; Michailidou 2001, 93–4.

[152] Liverani 1979, 62–3; Borgna 1995, 40.

[153] Melena 2014, 151–52; Palaima 2015, 629–31.

[154] Dialismas 2001, 130; Palaima 2015, 629–33.

[155] Michailidou 2008, 529; Palaima 2015, 632–33.

[156] Muhly 1980, 44.

[157] Del Freo 2005; Michailidou 2008, 530.

[158] Palaima 2015, 632–33.

[159] Palaima 2004, 99, 113; Nakassis 2013a, 244.

[160] Palaima 2015, 633.

[161] Borgna 1995, 31.

Thebes (Arsenal), and Mycenae (Tsountas and Mylonas caches), all of which contain a mix of serviceable and broken tools, scrap, and finished but possibly unused products (table 4).[162] The Schliemann hoard from Mycenae's citadel could be another example, though it contained only two of the tool types (double axe and knife) repeated in other assemblages.[163] The rarity of metalworking spaces at Mycenaean centers suggests that these citadel hoards were in the possession of an official rather than a smith.[164] Their contents could include materials collected from outlying districts, and the *qa-si-re-we* would then have divided and distributed items from this stock to dependents of the palace. Complete copper ingots occur in the Tsountas and Mylonas assemblages—both safeguarded within the Mycenae citadel. Ingots could be broken down and distributed in pieces when needed. The hoards also preserve finished (or nearly finished) objects perhaps produced expressly for the palace. The Athens and Tsountas hoards yielded castings for a dirk and sword (which needed further refinement and sharpening of their blade edges), while the Athens hoard also had bronze disks that might serve as mirrors.[165] The Tsountas hoard oddly contained a horse bit lacking any apparent damage, while the Schliemann hoard included two undamaged model wheels. These well-preserved objects are hard to explain but could represent items manufactured for the palace through *ta-ra-si-ja* work (see table 4). It is worth highlighting here Gillis' controversial hypothesis that the Pylian *ta-ra-si-ja* metal records refer to administrative oversight of *finished products* rather than the traditionally understood disbursements of raw material.[166] While it is difficult to disassociate *ta-ra-si-ja* metal from the notion of palatial allotments, Gillis is undoubtedly correct in emphasizing that authorities tracked the types of metal items that came into the palatial centers in addition to those that left.[167]

The retention of broken implements in these stock collections, furthermore, suggests the palatial collection of damaged items. The Jn 829 tablet reveals that Pylian authorities gathered recyclable bronze from the kingdom's various regions. If palaces distributed work tools, laborers might reasonably return these implements after use regardless of their condition. In this scenario, dependent workers lacked the authority to recycle loaned tools and were required to return broken implements to prove their unusable condition. Palatial authorities might then send out the broken items for recycling or repair and refurbishment. Killen has argued that such actions do not fall under the *ta-ra-si-ja* organizational model but rather fit Linear B descriptions of *o-pa* work; he notes that records from Pylos (Sh 736) and Knossos (Ws 1704 and 8495) might reference the refurbishment of metal armor and javelins.[168]

A relevant assemblage for the issue of state property and its return is the Loftus hoard, which came to light in an early second-millennium Mesopotamian context at Tell Sifr (Iraq), near the city-state of Larsa.[169] With complete and broken metal items, the hoard contained primarily agricultural tools (e.g., sickles and digging implements).[170] As Moorey explained, this cache of broken tools and serviceable implements belonged to the city-state:[171]

> The varied contents of the metal hoard seem to be directly associated with an administrative procedure clear from texts dealing with agricultural implements in the early second millennium B.C. These not only record the total weight of implements, but often list the weight of individual tools. This was to ensure, with a certain percentage allowed for wastage, that the quantity of metal which came back after a season's use, whether sound or scrap, was equal to that originally issued. The Loftus hoard from Sifr may be part of such an end-of-season consignment.

[162] Borgna (1995, 18, 22–3) highlighted the similarity of the Athens, Mycenae Tsountas, and Mycenae Mylonas hoards in terms of individual components and context.

[163] For the Schliemann hoard, see Schliemann 1878, 111, figs. 120–25, and the online appx.

[164] Workspaces for metalworking have not been found at Mycenae, Pylos, Thebes, or Athens. Evidence for metallurgical activity, however, comes from Tiryns during the LH IIIB and IIIC periods; supra n. 38.

[165] The bronze disks are thicker than balance pans, which are found in Cypriot hoards. For Mycenaean mirrors, see Iakovidis 1982, 218, 223. Borgna (1995, 27) questioned the identification of the castings and doubted that the disks were mirrors.

[166] Gillis 1997, 511. She considers "*ta-ra-si-ja* not as an allotment in the case of *ka-ko* but as an obligation" (509).

[167] For a quantitative discussion of metal in the Mycenaean tablets, see Dialismas 2001; Michailidou 2001, 86–9, 92–3.

[168] Killen 1999, 328–30; 2001, 161. I thank Michael Lane for these references and for telling me about *o-pa* work in the Linear B tablets.

[169] Moorey 1971, 61–2; Postgate 1992, 226–28.

[170] Moorey 1971, 64.

[171] Moorey 1971, 84–5.

TABLE 4. Mainland hoards as palatial stock or *ta-ra-si-ja* metal allotments.

	Palatial Stock in Possession of or for a Metal Overseer (perhaps the *qa-si-re-we*)	Material Given to a Smith as Part of a *ta-ra-si-ja* Arrangement
Examples	Mycenae: Mylonas, Tsountas, Schliemann(?); Athens Acropolis; Thebes Arsenal	Mycenae: Poros Wall; Orchomenos; Anthedon
Notable traits	Palatial context	Outside citadel context
	Complete, functional tool set	Complete, functional tool set
	Mix of complete and broken tools and other fragmentary items	Deliberate severing or modification of objects: signs of rationing?
	Finished products, perhaps new	Distribution of prototypes(?) to smiths for reproduction or repair
	Sword casting (Tsountas)	
	Horse bit (Tsountas)	
	Dirk casting (Athens)	
	Disks, for mirrors(?) (Athens)	
	Model wheels (Schliemann)	
Nonscrap workable metal	Copper ingots	Copper oxhide ingot pieces (Poros Wall)
	Oxhide ingot (Tsountas)	
	Slab ingot (Mylonas)	Bronze bun ingot (Poros Wall)
		Matte and furnace lining (Poros Wall)
		Lumps of metal dubiously identified as "slag" (Anthedon)

Old Babylonian tablets support this interpretation of the Loftus hoard; text and archaeology confirm the state's distribution and collection of metal objects—namely farming tools.[172] If there were state-level concerns about the quantitative measurement of metal at the distribution stage, one would expect an equal concern at the return phase. Postgate's summary of the Loftus hoard and its interpretation is useful in considering Mycenaean metallurgy: "The records of the institutional metal-workshops automatically record the weight of metal items, and it is clear that artefacts were regularly recalled to be melted down and reformed."[173] The Loftus hoard offers a Bronze Age example of how officials stockpiled and tracked metal items such as tools, regardless of their preservation.

Hoards as Metal ta-ra-si-ja Allotments from the Palace

Although only Pylos provides textual evidence, Mycenaean authorities likely controlled metal at several other palaces. Three hoards—the Mycenae Poros Wall, Orchomenos, and Anthedon examples—may even represent remnants of a *ta-ra-si-ja* arrangement between semidependent smiths and centralized authorities (see table 4).[174] These assemblages have higher quantities of broken objects that seem to be scrap, and they do not come from palatial storage ar-

[172] A comparable arrangement is evident in the textual record from Ugarit (Liverani 1979, 62–3).

[173] Postgate 1992, 228.

[174] Borgna (1995, 13–15) highlighted the similarity of these particular hoards, though she does not interpret them as *ta-ra-si-ja* goods.

eas.[175] Anthedon is not a Mycenaean center, but the possessor of that hoard might have relied on Thebes for economic support. The Anthedon hoard included, along with numerous broken metal objects, serviceable examples of the same recurrent types of tools found in palatial stocks; this composition could mark the Anthedon assemblage as originating from a central authority. Perhaps the Kalydon hoard (with all the repeated tool types except the narrow chisel), which was found in a field 2.5 km from the site, reflects a similar connection between a rural assemblage and a center.

More than a dozen pieces of copper oxhide ingots in the Poros Wall hoard suggest raw material dispersed from the palace at Mycenae. While the Tsountas and Mylonas assemblages, interpreted above as palatial stock, stored complete ingots, the Poros Wall's copper had been broken and divided by officials, perhaps the *qa-si-re-we* metal overseers. Metallographic analysis has shown that these ingot fragments consisted of copper with inclusions of other elements such as sulfur and iron.[176] This chemical composition, which is distinct from oxhide ingots found on Crete, suggests that the origin and production processes of the Poros Wall ingot fragments differed from those of the Minoan examples.[177] Differences thus clearly exist between the Mycenaean and Minoan metallurgical industries including minor variations in the raw copper material. The Poros Wall hoard also contained a bun ingot made of bronze (ca. 86% copper and 11% tin).[178] The presence of a bronze bun ingot alongside copper fragments appears to show the distribution of copper and bronze in palatial allotments, perhaps demonstrating that the *140 (AES) ideogram and *ka-ko* word in the Jn series can refer to both metals.[179] The Poros Wall hoard also implies the distribution of other metallurgical material. Muhly identified copper-iron-sulfide pieces in the hoard as matte and other metal fragments as pieces from the lining that formed on the interior of a furnace during metal processing.[180] Metal matte is an intermediate product in the transformation of copper sulfide ores to pure copper during the smelting of cupriferous ores.[181] Such matte is otherwise unattested at Mycenae or any other Mycenaean palatial site. As noted above, there is no archaeological evidence at Mycenae of work areas for even simple metallurgical activities such as melting and casting metal. Indeed, the absence in the hoard of other archaeometallurgical remains (e.g., crucibles, tuyeres, and molds) implies that the pieces were not remnants of a local metalworking event. However, the inclusion of the matte product and pieces of furnace lining does provide additional evidence for a metal shortage at the end of LH IIIB. These remnants of metallurgical activity—wherever it may have transpired—were saved to ensure no loss of metal and were apparently distributed to the smith for the extraction of any remaining bits of copper.

The Anthedon collection may also contain metallurgical remains. In addition to scrap metal, there was a substantial quantity of material (13–18 kg) described by its excavator in 1890 as "bronze slag."[182] This material is the only slag reported from a second-millennium Aegean hoard, and there has been no metallographic study of its composition. It is thus possible, perhaps even likely, that this material represents usable quantities of metal (either copper or bronze) rather than by-products of smelting activity.[183] Whatever the actual composition of the Anthedon slag-like material, it seems to support the hoarding and possible distribution of low-quality metallurgical materials for future processing.

Traces of intentional partitioning of tools in these possible *ta-ra-si-ja* allotments may reflect measures taken to apportion metal. The shaft-hole sidewalls of fragmentary double axes occasionally show signs of bending that indicate deliberate severing. Two double

[175] Spyropoulos 1972, 200–2; Knapp et al. 1988, 254; Borgna 1995, 15–6.

[176] Knapp et al. (1988, 256) reported 16 oxhide ingot fragments, while Gale (1989, 254, fig. 29.15) counted 12 such pieces. For the results of chemical analysis on these pieces, see Mangou and Ioannou 2000, 214–15, table 4.

[177] Mangou and Ioannou 2000, 214–16. Cf. Gale 1989, 254; 1991, 227.

[178] Mangou and Ioannou 2000, 214–15, table 4.

[179] Muhly 2009, 19; Melena 2014, 140.

[180] Muhly 1976, 93; Knapp et al. 1988, 256.

[181] Muhly and Kassianidou 2012, 129. Metal matte would have required further processing before it could be used for casting metal objects.

[182] Rolfe 1890, 99–100, 106–7; Spyropoulos 1972, 62, 200; Knapp et al. 1988, 254.

[183] I thank Vasiliki Kassianidou for alerting me to the possibility of the slag misidentification, which has also occurred elsewhere. Lumps of copper from LBA tombs in the Limassol region of Cyprus, for instance, were considered slag before a proper study revealed the true nature of the material; see Charalambous and Kassianidou 2012, 302–3.

axe fragments from the Orchomenos hoard illustrate this point. The first (fig. 7) shows the shaft-hole sidewall bent backward and severed. Another double axe half (fig. 8) bears tool marks (possibly from a chisel) along its shorter shaft-hole sidewall, indicating that it was intentionally cut off. Double axe halves might work well as wedges, yet it is surprising that such severed double axe halves do not match a corresponding half in Mycenaean hoards. Like the Orchomenos cache, the Anthedon and Athens Acropolis hoards contain two nonjoining double axe halves (figs. 9, 10). It is plausible that palatial authorities, perhaps the *qa-si-re-we* officials, broke apart damaged tools and dispensed the pieces for reuse (as a wedge) or recycling. It is intriguing that the presence of cold-working metallurgical tools (e.g., a file, anvil, and hammer) in the Athenian cache could have facilitated the deliberate fragmentation of objects in that collection. Alternatively, fragmentary tools could reflect state property returned to the palace after use.

Related to the severed implements are folded tools, stripped of their original functionality. The Orchomenos hoard contained a single-edged knife with the blade entirely bent backward (fig. 11). The Mycenaean Poros Wall hoard had several bent or folded implements including two long knives (identified previously as sickle fragments), a short knife, and a broad chisel (figs. 12–14) as well as a folded and unusable sword.[184] These items recall the practice of intentionally "killing" an object to remove it from circulation as well as Borgna's argument that the palaces deliberately eliminated metallic wealth by placing it in foundation deposits.[185] Other interpretations of intentional destruction and object modification exist.[186] Chapman has discussed deliberate fragmentation in European hoards and the fragmentation of various materials in the Aegean Bronze Age. According to him, a deliberately broken object may take on a new function that prolongs its use-life.[187] Following this logic, Harrell proposed that the deliberate fragmentation of certain swords in the shaft graves at Mycenae reflects a practice of removing pieces of old blades for the creation of new ones: "Casting new swords from pieces of old blades would have interwoven the life histories of blades and humans even more tightly together, as swords are imbued with the ability to be born, die, procreate, and be reborn."[188] In the case of the Mycenaean hoards, a simple, utilitarian explanation for the modification of tools and weapons seems apt: palatial authorities on the Greek mainland may have intentionally deformed particular objects to earmark them for recycling. The action would clearly differentiate functional from nonfunctional items among the heterogeneous materials in Mycenaean hoards.

Though portions of the Poros Wall, Orchomenos, and Anthedon assemblages were undoubtedly meant for a foundry, these hoards also fit the image of state-allotted *ta-ra-si-ja* materials (see table 4). Each includes a fair amount of scrap, broken implements, and raw materials alongside well-preserved tools. These hoards are thus more complicated than random collections unified solely by a metal denominator; their contents need not be entirely for melting and recasting. Why recycle highly functional implements, such as the Orchomenos tool set? As suggested above, the working tools could be included as models for reproducing similar tools, and the hoarding of vessel handles and parts of tripod stands could have the same purpose. Such fragments unaccompanied by other pieces of the original objects may represent scrap, spare parts for repairs, or examples for the fabrication of molds. Single metal handles occur in the three *ta-ra-si-ja* hoards discussed here; is this iteration a coincidence or a sign of careful selection? If palatial metal vessels warranted repair from time to time, spare parts, such as legs and handles, could have been manufactured according to specific directions and standards. In this context, it is noteworthy that the scribes of the Ta tablets invento-

[184] Wace 1953.

[185] Borgna 1995, 40–3; see also a brief discussion of the issue in Knapp et al. 1988, 239–40. For an example of the ritual killing of Mycenaean pottery, see Soles 1999.

[186] Discussion about the transformation of hoarded tools should take Dietrich's (2014, 475) analysis of Carpathian caches into consideration; he observed that certain socketed axes have "an end of use-life marked by reworking into a container and by deposition." Carpathian hoard owners refashioned these axes to hold fragments of smaller tools, thus creating miniature hoards within a larger assemblage.

[187] Chapman 2000, 2015. Chapman (2015, 43) notes: "I have suggested that the Fragmentation Principle remains central to research into material culture, both within the Aegean Bronze Age and in other times/places."

[188] Chapman 2015, 43; Harrell 2015, 150–51. In his analysis of hoards from Bronze Age England and Wales, Wiseman (2018) argued against such fragmentation narratives by employing a quantitative model that indicates nonstructured collections and random object fragmentation in his hoard data set.

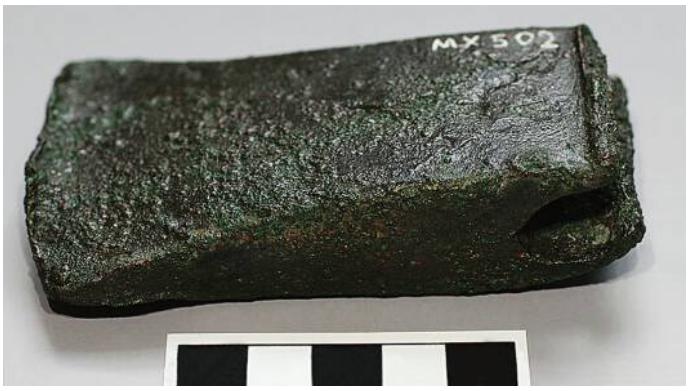

FIG. 7. Severed half of a double axe from the Orchomenos hoard. Archaeological Museum of Chaironeia, inv. no. 502 (courtesy Archaeological Museum of Chaironeia).

FIG. 8. *Left,* half of a double axe from the Orchomenos hoard; *right,* detail of the severed edge. Archaeological Museum of Chaironeia, inv. no. 503 (courtesy Archaeological Museum of Chaironeia).

ried legless tripods at Pylos. Perhaps the tripods were intended to be repaired, especially if they were valued heirlooms, as Palaima argued.[189]

CONCLUSION

The presence of repeated groups of tools in metal hoards has not been previously recognized because of the fragmentary nature of many implements in the caches, the assemblage of diverse and seemingly unrelated objects, and overly simple interpretations of hoarding behavior. This paper has identified a standard set of functional tools that occurs, along with broken implements (sometimes deliberately severed or bent), in seven Mycenaean hoards. The repeated tool types include a double axe, two distinct chisel forms, a knife, and a sickle. The selection of these tools, some of which were not commonly available on the mainland, appears to have been part of the deliberate organization of the hoards. Such hoard structure at the end of the 13th century B.C.E. seems meaningful, and the archaeological context of some of the hoards

[189] Palaima 2003, 198–99; 2004, 113–14. I thank James Wright for making this suggestion to me.

FIG. 9. Two nonjoining halves of double axes from the Anthedon hoard. National Archaeological Museum, Athens, inv. nos. 18180, 18181 (courtesy National Archaeological Museum, Athens; © Hellenic Ministry of Culture and Sports/Archaeological Receipts Fund).

FIG. 10. Two nonjoining halves of double axes from the Athens Acropolis hoard (© Acropolis Museum).

FIG. 11. Folded-over single-edged knife from the Orchomenos hoard. Archaeological Museum of Chaironeia, inv. no. 542 (courtesy Archaeological Museum of Chaironeia).

implies palatial influence. The complexity of the Mycenaean assemblages also demonstrates that palatial authorities monitored all types of metal—serviceable objects, raw materials, and scrap—during an apparent copper/bronze shortage.

To judge by the repeated tool types, Mycenaean palaces likely distributed tools to semidependent workers. In this scenario, officials could have required the return of all implements, whether complete or broken. The mainland's palatial hoards comprise a mix of functional and damaged tools, raw materials, miscellaneous scrap, and finished products. Assemblages affiliated with palaces can be divided into two categories: palatial stocks of metal and allotments given to smiths in a *ta-ra-si-ja* arrangement. Hoards thus represent an underappreciated context for understanding Mycenaean metallurgy. They enhance the image portrayed by the Pylian tablets detailing the palatial management of metal.

The complexity of the Mycenaean hoards in terms of overall size, the blend of complete and fragmentary items, and the greater variety of objects stand out when compared with Cretan examples. Based on their contexts and repetitive tool groupings, some mainland assemblages indicate administrative control of metal

FIG. 12. Bent long knives from the Poros Wall hoard at Mycenae . National Archaeological Museum, Athens, inv. no. P 7646 (courtesy National Archaeological Museum, Athens; © Hellenic Ministry of Culture and Sports/Archaeological Receipts Fund).

FIG. 13. Bent short knife from the Poros Wall hoard at Mycenae . National Archaeological Museum, Athens, inv. no. P 7647 (courtesy National Archaeological Museum, Athens; © Hellenic Ministry of Culture and Sports/Archaeological Receipts Fund).

FIG. 14. Bent broad chisel from the Poros Wall hoard at Mycenae. National Archaeological Museum, Athens, inv. no. P 7650 (courtesy National Archaeological Museum, Athens; © Hellenic Ministry of Culture and Sports/Archaeological Receipts Fund).

resources and objects, a phenomenon that is difficult to substantiate on Crete. Perhaps this difference is unsurprising given the ubiquity of copper and bronze in Neopalatial Crete and the apparent decline of such supplies on the 13th-century mainland. Metal seems to have been more widely available on Crete than the mainland throughout the second millennium B.C.E., as the number, distribution, and chronological span of Cretan hoards suggest (see online appx.). Though several hoards have come to light at Knossos, they date to the Neopalatial period (ca. 1700–1450 B.C.E.).[190] These assemblages fail to indicate if the later Mycenaeans at Knossos monitored metal in the way that the late 13th-century mainlanders did. Killen believed that Mycenaean Knossosians used the *ta-ra-si-ja* system for metal administration, but no Linear B tablets verify this idea despite the evidence for *ta-ra-si-ja* arrangements with other materials on Crete.[191]

The Linear B records from the Palace of Nestor, though much debated, provide a distinct picture for the Mycenaean administration of metal and for the region's metallurgical industry. Unfortunately, an LBA metal hoard has not come to light in Messenia, yet the caches found in other Mycenaean contexts suggest that *ta-ra-si-ja* metal arrangements occurred at contemporary mainland centers. The Mycenaean hoards, when combined with the Pylian Jn and Ja series, support the notion of a metal shortage on the mainland and may shed light on the specifics of metal *ta-ra-si-ja* exchanges and expectations.

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[190] Evans 1928, 627–42.

[191] Killen 1987, 69.

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