The Transformational Power of the Sea: Copper Production in Early Bronze Age Greece

DOI:
10.5325/jeasmedarcherstu.8.3-4.0287

Document Version
Accepted author manuscript

Citation for published version (APA):
Berg, I. (2020). The Transformational Power of the Sea: Copper Production in Early Bronze Age Greece. *Journal of Eastern Mediterranean Archaeology and Heritage Studies*, *8*(3-4), 287-298. https://doi.org/10.5325/jeasmedarcherstu.8.3-4.0287

Published in:
Journal of Eastern Mediterranean Archaeology and Heritage Studies

REVISED MANUSCRIPT

The transformational power of the sea: Copper production in the Early Bronze Age, Greece

Author biography:

Ina Berg is a Senior Lecturer in Mediterranean Archaeology at the University of Manchester (UK). Her areas of interest are Aegean archaeology (with particular emphasis on the Cycladic islands), island archaeology, ceramics studies (including X-radiography and CT scanning), experimental archaeology and the archaeology of skill. She recently published *The Cycladic and other Aegean Islands in Prehistory*, a major academic synthesis of the prehistory of the Aegean islands from the Palaeolithic through to the Mycenaean era.

Abstract:

The sea tends to shape people's lives in a myriad of practical and symbolic ways. This paper argues that it is therefore unsurprising that the sea also impacted on copper workers in the Southern Aegean during the Early Bronze Age. Here, the sea was an integral element of the copper production which is characterised by movement of metal across the sea from one manufacturing stage to the next – often over considerable distances requiring lengthy absences of the workers from their home communities, making metal workers true maritime specialists alongside the more 'typical' traders, fishermen and seafarers. The distances travelled magnified the symbolic value of the raw materials as the object's geographic distance became converted into a symbolic value-added 'exotic' distance. This value was further enhanced thanks to the

mastery of skills required to traverse the sea, an element very different from land and intimately associated with forgetting, disposal and death.

Keywords: metallurgy, sea, away place, enchantment, mobility, identity, exotic distance

Introduction

Green copper ore malachite is mined at site A, it is broken down and pulverised nearby before being transported by sea to Site B, some 50 km away, to be smelted at a facility utilised by many manufacturing groups. The smelted metal travels a further 275 km to Site C where it is melted and then poured into a mould – emerging as a shiny reddish copper object ready to be used. Familiar from modern-day manufacturing supply and manufacturing chains, this example actually stems from the Early Bronze Age Aegean where each stage of copper production appeared to have been distinctly separately in space and time. It is the contention of this article that the transformation of copper from unprepossessing rock into a hard, usable object, and its symbolic value, are deeply affected by the elemental, spatial and temporal properties of its journey across the Mediterranean Sea, and it is these elements that assign meaning and social value to copper objects in the eyes of the users.

The geography of metal in Early Bronze Greece

Metallurgy first emerged in the Aegean during the Final Neolithic (ca. 4200-3200 BC). However intensified, large-scale and diversified production of copper, lead and silver is only attested in the succeeding Early Bronze Age (EBA) (ca. third millennium BC). Silver and lead were sourced from the mines at Lavrion (Attica) and from the island of Siphnos. Copper originated from the islands of Kythnos, Seriphos, Siphnos, and Lavrion. Aside from the rich multi-metallic mines at Lavrion that were utilised over millennia, metal sources in the western Cyclades were generally small to medium in size and were probably intensively exploited only for relatively short periods of time before being exhausted.

Determination of an ancient metal source has been made on the basis of three types of evidence: a) traces of mining, b) tools, facilities and by-products indicative of metal processing, or c) chemical analysis of the finished products. Of these, indications of actual mining activity are the most reliable type of evidence, but they are rather elusive because later mining work has normally destroyed signs of earlier use. Even if traces are present, dating evidence, such as diagnostic pottery, may be absent or not associated stratigraphically. Currently, the only evidence of (open air) copper mining from the Cyclades comes from Kythnos (Cape Tzoulis, Aspra Kellia, Petra) (Georgakopoulou 2016: 50). Evidence of copper processing may include tools (e.g. hammer, smelting furnace, casting mould), work areas (e.g. shelters, specialised work areas) and waste materials (e.g. slag, prills) used in the different operational stages. Georgakopoulou (2016: table 4.1) has collated at least 13 sites that show evidence of EBA copper smelting (Fig. 1). The most impressive sites are undoubtedly the large slag heaps on Seriphos that indicate thousands, if not hundreds of thousands, of individual smelting events. While metal processing finds are relatively common and are often reasonably well dated directly or through association with dated settlement finds nearby, slag heaps remain a problem due to a lack of associated datable finds and the absence of a firm stratigraphy. Associating an ore source with nearby evidence of rock beneficiation (e.g. crushing, grinding) can be done much more reliably than with one of the later processing stages as the assumption is that this time- and labour-intensive activity was undertaken near the metal source itself. In contrast, smelting may either take place in the immediate vicinity or be geographically distant from the ore source and thus will require lead isotope analysis before an origin can be confirmed. Lead isotope analysis of finished objects is, however, the most common way to determine a source of metal, though its resolution is normally limited to the island, rather than identifying a specific mine.

Drawing on archaeological evidence of tools and equipment, work areas, waste products, and finished artefacts, scholars have been able to reconstruct the production sequence of copper objects with some accuracy (Table 1) (Georgakopoulou 2016: fig. 4.1; Betancourt 2006: 179-189): after having located suitable rock, the ore needed to be extracted. Evidence of tool marks and stone tools in mines as well as contemporary ceramics provide evidence of the first stage of the operational sequence. The second step is to concentrate the quality of the ore, a process called beneficiation, which was done by crushing or grinding the ore. Stone tools and discarded rock and ore fragments provide clues as to this phase which was normally carried out near to the source. Applying heat to this selected ore material sets a chemical process in motion that liquifies, and hence separates, the metal from the rock and allows it to be collected. The heating of this crushed ore was normally undertaken in perforated cylindrical clay furnaces whose heat was regulated using bellows, although fixed or portable hearths were used at some sites (e.g. Akrotiraki on Siphnos, Kastri on Syros, Markiani on Amorgos, Akrotiri on Thera) (Bassiakos and Philaniotou 2007; Doumas 2011: 167; Georgakopoulou 2016: 61). Crucibles were used to collect the liquid metal. Slag, the stony waste by-products from smelting operations, is often found discarded in heaps that range from small to enormous in size. The largest of these slag heaps is Avessalos on Seriphos which is estimated to contain 100,000 tons of slag.[1] At Skouries on Kythnos, excavators found 20 schist-built circular structures of ca. 4 m diameter most likely contemporary with the nearby slag heap. The only excavated circular structure contained a furnace bottom in the floor, and it is therefore likely that they represent metallurgical working areas (Catapotis 2007: 213). Smelting sites have been found near mines as well as at considerable distance – the largest known distance travelled being ca. 300km from Lavrion (Attica) to Chrysokamino (Crete). The last step in the metallurgical process is to turn the refined raw material into a finished object by casting or hammering. Evidence of tools, moulds and furnaces (and sometimes also slag if there is re-smelting) gives clues as to the location of these workshops which are generally located in settlements (e.g. Poros-Katsambas: Wilson, Day and Dimopoulou-Rethemiotaki 2008; Aghia Photia-Kouphota: Tsipopoulou 2007: Kastri on Syros: Georgakopoulou 2007: 131).

Spatial and temporal mobilities of copper-working

The production sequence briefly outlined above emphasises the great mobility of materials and people involved in making copper objects during the Early Bronze Age. This mobility is expressed both spatially and temporally.

The *spatial* picture that presents itself is a very diverse one. While mining and crushing of ore is normally undertaken close to the mine itself, smelting - and even more so the melting and final casting stage - often took place at considerable distance and may even involve travel to an entirely different island. As regards smelting operations, scholars distinguish between small and

[1] Despite evidence that part of this slag heap accumulation can be unequivocally dated to the EBA, a multi-period use of this site cannot be excluded (Philaniotou, Bassiakos and Georgakopoulou 2011).

large slag heaps (Table 2). Small slag heaps are most likely the result of small-scale local smelting events near a source of surface copper that was discovered, mined and the ore smelted on the spot. Examples of this practice can be found on Kythnos (Sideri, Paliopyrgos), Keos (Aghios Symeon), Keros (Konakia) and Siphnos (Petalloura) (Catapotis 2007; Georgakopoulou 2016).[2] In contrast, large slag heaps seem to be used for smelting metal both from local sources and from other islands; they are normally not associated with any settlement. Scholars have stressed that there is no chronological patterning to this phenomenon, but that this mixture of small, large, near and remote EBA smelting sites co-existed (Georgakopoulou 2016: 56).

The three largest slag heaps are Skouries on Kythnos, and Kephala and Avessalos on Seriphos. The estimated amount of slag at these sites is 5000, 5000 and 100,000 tons respectively which, in turn, has been calculated to be the by-product of 125,000-250,000, 125,000-250,000 and 2,500,000-5,000,000 individual smelting events (Catapotis 2007: Table 12.3 – adjusted according to Philaniotou's revised estimate for Skouries; Philaniotou, Bassiakos and Georgakopoulou 2011: 159). These numbers are extremely large, though perhaps not all that surprising when recalling the 20 circular, schist-lined working activity areas at Skouries on Kythnos. Assuming that each of these working areas required three to four craftspeople and were indeed contemporary, then sixty to eighty individuals could have operated there at any given time (Catapotis 2007).

[2] We now also have evidence of small-scale EBA copper smelting activity near or even inside habitation sites (e.g. Raphina in Attica, Kolonna on Aigina, Skali on Siphnos, Ayia Irini on Kea and Daskaleio-Kavos off Keros) (Catapotis 2007; Georgakopoulou 2016: table 4.1).

Lead isotope analyses for Skouries on Kythnos indicate that copper smelted here came from Kythnos itself, Siphnos, Kea and possibly Seriphos (Stos-Gale 1993, 1998), and it is entirely possible that the circular structures were built and used by metal specialist communities who had travelled to Kythnos from other islands. Lead isotope analysis from Keros shows a variety of profiles which also hints at diverse source origins predominantly from the western Cyclades (Georgakopoulou 2007, 2018). Further afield, the smelting site of Chrysokamino on Crete also received crushed ore from the western Cyclades (Kythnos and Seriphos) and Lavrion (Stos-Gale and Gale 2003; Stos and Gale 2006). This long-distance movement of raw materials finds support also in lead isotope analysis of Early Minoan – Middle Minoan II artefacts that show Lavrion and the western Cyclades to be the dominant copper sources for Crete (Stos-Gale and Gale 2003; Stos and Gale 2006) the same applies to finished copper objects from the Greek mainland (Kayafa, Stos-Gale and Gale 2000). As Table 3 shows, the distances between source island and smelting site, even if they are neighbouring islands, can be considerable, ranging from a relatively modest 30 km journey between Kythnos and Seriphos to a lengthy multi-day voyage of ca. 325 km between Lavrion in Attica and Chrysokamino on Crete.

Scholars frequently remark upon locational preference for isolated smelting sites which seem to combine inherently practical considerations with social concerns. Among the practical issues were the sites' orientation: a north-facing promontory where craftspeople could utilise the predominant northerly winds that persisted throughout the entire year, but were particularly strong during the summer (Berg 2019: Fig. 2.7), to supply natural draught for the operation of the smelting furnaces (Bassiakos and Philaniotou 2007: 50; Georgakopoulou, Bassiakos, Philaniotou 2011: 142; Philaniotou, Bassiakos and Georgakopoulou 2011: 158). A more social aspect of the locational choice is visible in the use of a steep, isolated promontory overlooking the sea whilst using fire and smoke which, according to Broodbank, showed the workers' concern for a "deliberate mixture of secrecy and advertisement" (2000: 294). Since 2000, however, evidence of smelting in habitation sites has come to light, throwing some doubt on the assumption of intentional secrecy proposed by Broodbank. A defensive location of these sites, as argued by Bassiakos and Philaniotou (2007: 51), seems also unlikely since, similar to the pattern observed also for obsidian extraction on Melos (Torrence 1982), scholars have not found any evidence indicating control over copper sources or smelting sites, and the general consensus is that access to these resources was free and that arrangements about who travelled and who did the processing of the ores probably varied (Broodbank 2000: 294; Georgakopoulou 2016: 59). While practical explanations of the choice of these iconic smelting sites might not be that convincing, the confluence of an island location, the sea and northerly winds might have conferred a particularly potential symbolic power to such locales which helped bestow a perceived potency or energy on the metal by virtue of this fusion of elements. Perhaps, in the same way as metalworkers were changing the properties of copper by adding tin or arsenic, sea breezes, promontories and the sea were equally essential ingredients that helped craftspeople create the 'right' kind of copper (pers. comm. Melanie Giles)? Certainly, the 'bundling' of the sensory experience, including the smell of the fragrant land, salty seas and burning fuel and ore, the audio-visual stimuli of the sea's waves and winds as they lap against the coast and brush over the land, and the tactile sensation of heat emanating from the hot furnace combine to make this a truly special and memorable transformative act (Turner 1986; Hamilakis 2013).

The *temporal* dimension of metal processing is a direct result of the spatial segmentation described above. The apparent need for movement of the raw material between processing stages has important time implications – even more so since transport had to be by sea which was less predictable than land transport. While we can discount tides and currents as major factors impacting on sea movement in the Aegean Sea (Mediterranean Pilot 2000), winds can aid or hinder travel greatly: winds that are too strong or blowing from an inopportune direction will require seafarers to wait for calmer conditions. With 50-75% of (modern) Cycladic wind data classified as Beaufort 1-5 (i.e. 'calm' to 'fresh breeze'), sea travel would have been possible, in principle, throughout all of the year (Berg 2019: Chapter 2). As the sail only made its appearance at the end of the Early Bronze Age, we have to assume that sea travel prior to this relied on boats and rafts that were rowed or paddled. Alongside small boats made for short journeys and only suitable in size for one or two rowers, we also have evidence of longboats (estimated to have been up to 19 m in length and providing space for 25 oarsmen) for whom Broodbank (2000) postulated a daily travel range of 40-50 km. Even at these much greater speeds, a hypothetical 275km-long voyage from Kythnos to Chrysokamino on Crete would take at least 6 days, assuming that wind and weather did not enforce lay-overs. Thus, the spatial separation of the operational sequence was matched by a temporal displacement as movement from one location to another may have taken days, if not weeks, thus forcing metal workers to leave home for long periods of time.

Copper = exotic distance + sea

Two consequences emerge from the spatially and temporally segmented manufacturing process: First, the origin of copper became thoroughly obscured. Second, the transformation of metal from ore into a finished object was intimately bound up in its voyage across the sea, an element that is associated with secrecy, forgetting and, indeed, death.

Unlike modern manufacturing or food packaging labels which always state the country or town of manufacture/origin, Early Bronze Age copper production was entirely unconcerned with identifying a specific source. The movement between locations for each separate manufacturing stage, and indeed often between islands, had the effect of obscuring the origin of metal; not to mention the possibility of metal-mixing (Doonan and Day 2007: 8). Likewise, smelting copper at sites that attracted specialists from many islands helped further mask the true origin of a particular smelt.

Much has been written by scholars about the role of objects of Cycladic origin (or sometimes local imitations thereof) in EBA I-II Crete where they made an appearance in cemetery and settlement sites particularly along the northern coast (e.g. Pyrgos burial cave, cemeteries at Gournes, Petras and Aghia Photia, settlement of Poros-Katsambas). In the case of Aghia Photia, Cycladic material is so prevalent that scholars have argued not just for influence, but actual settlement by Cycladic islanders on Crete (Broodbank 2000: 302-3; Davaras and Betancourt 2004, 2012). Where Cycladic objects were deposited within typical Cretan communal burial contexts, they appear to be used as status-enhancing symbols. The best evidenced examples are the two EBA burial tholoi in Archanes (Panagiotopoulos 2002; Papadatos 2005): Tholos Gamma and Tholos Epsilon are contemporary, and show considerable similarities in architecture and construction, but differ in the origin, quantity and quality of grave goods. Tholos Epsilon contained artefacts, ornaments and figurines of predominantly Cretan manufacture. Fifty percent of all grave goods from Tholos Gamma, on the other hand, were of Cycladic origin and included copper daggers, marble figurines, beads and pendants. As Papadatos (2007) has argued, it is this access to finished objects and raw materials from the Cyclades that allowed families, kingroups or individuals to flaunt their wide-ranging exchange connections, wealth and status. This interpretation is based on the well-known phenomenon of extant or aspiring rulers and leaders to associate themselves with geographically distant places or peoples, most commonly through the import of foreign raw materials or finished artefacts, in order to enhance their power and authority (Helms 1988). It is through access to distant knowledge, goods and people that locals can demonstrate their greater control over the universe as a whole and legitimise their position within the community (Helms 1988). The import of a raw material – copper - not available on Crete, and/or finished objects that contain within them the knowledge of how to extract, process and cast rock into a functional finished object, fulfils this intended purpose well. It was sufficient for everybody to be aware that these raw materials or objects had travelled considerable distance, had originated from remote sources and been turned from rock into metal by skilled individuals. Their precise island origin or the actual location of the mine or smelting site was of no concern, a generalised notion of exotic distance being entirely sufficient. Comparisons may be drawn with the import of Roman Samian pottery from different production centres in Gaul into Britain. Gosden rightly queries whether the locals in Britain would have recognised that it came from distinct manufacturing centres. The long-distance networks involved in transporting this ware to Britain thus acted to obscure its ultimate unique origin and homogenise the product in the eyes of its consumers (2005). The value of these objects, thus, did not lie in the *actual* distances travelled or in identifying the actual individual maker, but their *perceived* remoteness and evident skill which established their exotic appeal. Gell (1998: 24) has drawn attention to another kind of obscured provenance, which is exemplified by the movement of ceremonial shells within the Kula ring. Here, the knowledge of the current owner (and lineage of previous owners) of each shell is of much greater importance than their original makers, thus conferring status and importance to those able to gain ownership of these objects in the present whilst obliterating their past histories. In this context, it would be the finished copper objects that might act as a 'container' for status, though the fact that many copper artefacts were utilitarian tools speaks against such an interpretation.

Was this obfuscating behaviour surrounding the processing of copper a deliberate goal or an unintended consequence of an informal production process? Doonan and colleagues (2007: 116) have argued for the former, though I am doubtful as this would require some degree of oversight and control to ensure that all metalworkers complied; this seems unlikely given the great variability in practices and the lack of control exercised over the raw material sources and metal processing sites. Given that craftspeople did not attempt to sign or mark their copper products in an attempt to profit from their craftsmanship, I am inclined to believe that the latter scenario is the more likely one.

What was, however, important, was the fact that copper-processing required raw materials to traverse the sea, a potentially dangerous liminal element whose mastery likely enhanced the value and reputation of objects and people alike as it required equipment, and considerable knowledge (e.g. of tides, wind, geography) and practical and conceptual skill (e.g. navigating, rowing/paddling/sailing) (Berg 2011, 2013). While the Mediterranean Sea is a much less menacing body of water than the oceans with their great tides, strong currents and dangerous sea creatures, it nevertheless can be a treacherous environment for seafarers as the many shipwrecks compellingly demonstrate; and like the heavy storms that repeatedly battered Odysseus' ship as he was travelling from Troy to Ithaka before eventually destroying his boat (Homer *Od*. 7.265-274, 9.69-76, 12.417-468). Given the dangers encountered, it should therefore not come as a surprise that many cultures, including the Minoan and Cycladic islanders, perceived the sea as a liminal space that humans traverse before reaching their ultimate destination or, indeed, as the place of death itself (Berg 2011 with references).

Evidence of an association of the sea with death during Late Minoan times is comparatively strong. Seventy-five percentage of the primary decorative motifs on Post-palatial (LM II-LM IIIC) burial larnakes from Crete show marine imagery – octopuses, argonauts, dolphins, boats and marine vegetation (Saunders 2008). Drawing also on evidence of marine motifs in contemporary floor decoration at Knossos and Ayia Triadha (Petrakis 2011), I previously proposed the possibility that the Minoans perceived the sea as a powerful liminal place that had to be crossed by the deceased before they can reach their final resting place (Berg 2013). Concrete evidence of Early Bronze Age beliefs does not exist as many Cycladic tombs were plundered by modern looters or published only in a preliminary fashion. Looting was also an issue on Crete where the continued use of multiple burial tombs over many centuries further impedes our understanding of burial customs and beliefs. However, a tentative indication of the role of the sea within Cycladic funerary beliefs may be gleaned from the location of the tombs and the positioning of the body within them. In the Early Bronze Age Cyclades, the dead were normally buried individually in cist cemeteries that were located at some distance from settlements, often on sloping hillsides (Doumas 1977). The deceased were placed in a strongly contracted position with the head facing away from the hill overlooking the surrounding environment. Importantly, in many instances, the cemeteries were positioned on sloping hills near the coast, thus allowing each deceased to establish a 'visual' connection with sea – perhaps indicating that the sea was the actual final resting place or, perhaps, that it served as a spiritual medium to transport the dead there.

An extension of the sea as a location of death is the power of the sea in permanently or temporarily aiding the forgetting by 'swallowing' objects, people and knowledge. This aspect is well established from later literary sources which consider the sea the "ultimate away-place" due to its depth, expanse, movement and ability to submerge things (Lindenlauf 2003: 423). An extreme example is provided by Homer who reports how one can dispose of enemies in the sea (*Iliad*, 21. 34-59). Lindenlauf identifies different disposal methods that include disposal from a boat in the open sea, from the coastal area (harbours or docks, work areas) or from towns into sewers that carry the object into the sea. And depending on whether disposal was unwanted or intentional, the sea was either regarded as a dangerous force that could take lives and dispose of objects permanently or a useful tool to make humans and things purposefully vanish (2003). Perceived as both negative and positive, the sea was therefore a location of death or exile as much as it was a powerful cleansing agent. It is the sea's ability to forget, to make invisible, to obscure in both metaphorical and also very practical ways that we see referenced in the spatial and temporal mobility of EBA copper production discussed above as the sea's meaning interweaves with that of the exotic distance.

Enchanting metal

Georgakopoulou (2016: 48) has emphasised the astounding alteration that copper undergoes as it is transformed from colourful stone into molten matter and finally re-emerges as a hard, shiny reddish metal object. Literature on metal and metal-workers has often drawn on these transformative aspects to assign smiths an almost magical or shamanistic position in society based on their ability to enact this elementary change (Williamson 1990), no doubt aided by the bundling of sensory performances that involved fire, heat, sounds and smells (Hamilakis 2013). The transformation that copper undergoes, and the virtuosity and technical skills embedded within the final emerging object, must have inspired powerful emotions, perhaps covering the entire spectrum from wonder to fear. As such, the finished objects, as well, as one could argue, their intermediate stages (e.g. ore, molten copper), are not mere symbols of a maker's intent but are agents in their own right which actively engage with their social world - what Gell would designate secondary social agents; that is entities "not endowed with will or intentions by themselves, but essential in the formation, appearance or manifestation of intentional actions" (Gell 1998: 36). These object-agents impact on their makers and users by creating or nuancing social relations, and assign meaning to them by shaping their identities and roles in society - they become enmeshed in social relationships. Copper objects thus contain the traces of their primary intentional agents, that is the metal workers, within their artefactual forms whilst, simultaneously, acting upon their makers and users. The reason why copper has the power to become a social agent lies in its ability to fascinate makers, viewers and users alike because the final object and the technical processes employed cannot be fully comprehended and are thus mysterious; they should therefore be regarded as 'technologies of enchantment' that control thoughts and actions of other human beings through the psychological effects they create (Gell 1992, 1998). The oft-cited example of an object as social agent are the beautifully carved and painted Trobriand canoe prow-boards which held a mediatory role in trade (Gell 1998: 96). As the Trobriand flotilla approaches its destination, these prow-boards are highly visible to the waiting exchange partners. Fascination with and power of these carvings act to dazzle and demoralise trade partners and thus induce them to bargain with less vigour and create a more favourable result for the Trobriands. The 'enchantment' agency of the prow-boards rests in the virtuosity of their design, and the superior skill and assumed magic that led to their creation. While notions of magic likely also applied to the different steps involved in copper production as craftspeople transformed a raw material from a solid to a liquid and back into a solid state, the final resulting products that were cast or hammered were too commonly available and were far too utilitarian in their purpose (e.g. tools, weapons and ornaments) (Branigan 1974) to meet the requirements for an enchanting object that can initiate action above and beyond enhancing the owner's status by referencing the rarity of the material, the skill embedded in the object and the great unknown distances traversed. Instead, I would argue that the main social agency that copper exerted was upon the self-awareness of the craftsmen and their communal identity. The twenty schist-lined circular metal workshop structures at Skouries that are located in close proximity to each other highlight that a place for sharing of knowledge and know-how was available as copper workers engaged in their daily craft; and the similarities in perforated furnace design across the islands show that this 'community of practice' actually interacted with each other (Wenger 1998). Instead of being individually recognised as virtuoso experts, our smelters' identity was thus expressed through shared metalworking practices that were unknown to outsiders and further obscured through the distances travelled.

An equally important element is the metallurgists' engagement with the sea which required a separate skills-set and enforced a unique lifestyle that required a craftsperson's absence from home for long periods of time, making them not only a material specialist but also a maritime long-distance specialist (Helms 1993; Sherratt 2007: 251). Whether the same metalworker accompanied his raw material through all production stages from mining to smelting or whether individuals specialised in separate processing stages is uncertain (Doonan, Day and Dimopoulou-Rethemiotaki 2007: 115-116; Sherratt 2007: 251-252), though the large slag heaps that indicate transport of metal ore from one island to another for primary smelting speak to the former scenario. Based on ethnographic case studies, Helms demonstrates that travel and craft specialisation are two aspects that are often intimately related and therefore often undertaken by the same individual (Helms 1993). This view is in agreement also with Kuijpers (2019: 30-31) who argues that greater division of labour among metalworkers only emerged with more complex and structured systems. An identity shaped both by metalworking skills and by long-distance travel (albeit over land) has also been posited for those working the ore at the Aibunar mines in Bulgaria during the Chalcolithic where ore was transported considerable distances to metallurgical smelting centres that also attracted ore from other mines (Cernych in Williamson 1990: 19).

Conclusion

Far from being a purely technological activity, copper-working has been shown to be an entangled web of relationships between people, objects, the sea and cultural-cosmological beliefs. The spatial and temporal separation of the various manufacturing stages imparts an additional degree of 'exoticism' that goes hand in hand with the astounding transformation of copper from rock into shiny metal. In addition, the journey across the sea, an element intimately associated with disposal, liminality and death, allows cosmological constructions of Aegean islanders to feed into their conceptualisations of copper. The fact that copper-working requires craftspeople to be away from home for extended periods of time and to travel long distances by boat, links the two crafts together: metallurgists are also long-distance maritime specialists which, in turn, impacted on their self-perception and identity as a distinct 'community of practice'. However, while other craft specialists might also travel longer distances to quarry their raw materials, their skill is potentially visible to all and there may be no attempts at obscuring the source origin. A useful contemporary example is provided by obsidian from Melos. Here, the more than 12,000 pieces of Melian obsidian at Mochlos, Crete, show evidence of the presence of all processing stage – from decortication to the finish object (Carter 2004). The same applies to Poros-Katsambas, the harbour settlement of Knossos. Thus, processing took place locally and craftspeople could be directly associated with the raw material, the various processing stages and the final, complete object. While also a good example of a community of practice, the lack of secrecy surrounding production and the awareness that obsidian came from one specific island in the Cyclades will no doubt have resulted in a different kind of identity for obsidian workers.

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Figure captions

Figure 1: Map of the Aegean with copper smelting sites indicated (after Georgakopoulou 2016: fig. 4.1) (Illustration by Pighill Heritage Graphics).

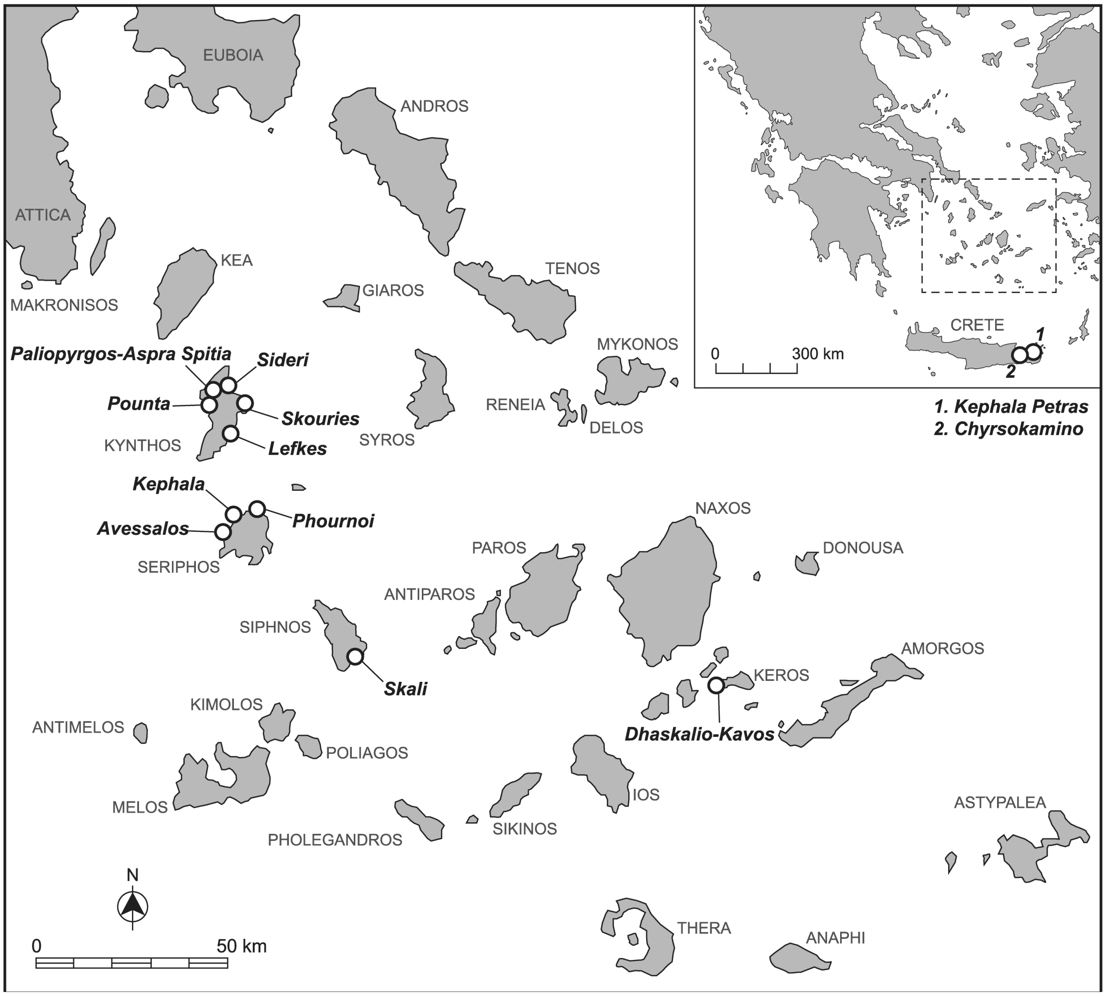
Table captions

Table 1. The production sequence of copper and supporting archaeological evidence (after Georgakopoulou 2016: fig. 4.1).

Table 2. Estimated sizes of slag heaps at copper smelting sites (after Georgakopoulou 2016: 51-52, table 4.1)

Table 3. Approximate distances between copper source islands and select smelting sites/islands.

Figure 1



EUBOIA
ANDROS
ATTICA
KEA
TENOS
GIAROS
MAKRONISOS
MYKONOS
Paliopyrgos-Aspra Spitia
Sideri
Pounta
Skouries
RENEIA
DELOS
KYNTHOS
SYROS
Lefkes
Kephala
Avessalos
Phournoi
SERIPHOS
NAXOS
PAROS
DONOUSA
ANTIPAROS
SIPHNOS
Skali
AMORGOS
KEROS
KIMOLOS
ANTIMELOS
Dhaskalio-Kavos
POLIAGOS
MELOS
IOS
ASTYPALEA
PHOLEGANDROS
SIKINOS
N
THERA
ANAPHI
0
50 km
CRETE
0
300 km
1
2
1. Kephala Petras
2. Chyrsokamino

Table 1

Production sequence	Resulting metal product	Archaeological evidence
MINING (extracting metal-rich rock)	Mined ore	Stone tools Tool marks in mines Ceramics
BENEFICIATION (crushing or grinding of mined ore with the aim of increasing the concentration of metal-rich ore)	Selected ore	Stone tools Discarded ore and rock fragments
SMELTING (separation of metal from ore through heat)	Metal	Slags Clay furnaces Bellows Crucibles Hearths Installations
METALWORKING (refining, casting, hammering, etc.)	Metallic artefact	Slags Moulds Tools Furnaces

Table 2

Estimated slag heap size	Site
Large (several thousands of tons)	Avessalos, Seriphos Skouries on Kythnos Kephala on Seriphos
Medium (one to a few tens of tons)	Phournoi on Seriphos Chyrsokamino on Crete Skali on Siphnos
Small (less than one ton)	Paliopyrgos-Aspra Spitia on Kythnos Sideri on Kythnos Dhaskalio-Kavos off Keros
Very small (a few pieces)	Kephala Petras on Crete Lefkes on Kythnos Pounta on Kythnos

Table 3

Route	Approximate Distance (km)
Kythnos-Seriphos	30
Kythnos-Kea	30
Kythnos-Siphnos	55
Kythnos-Chrysokamino (Crete)	275
Lavrion-Chrysokamino (Crete)	325