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Titelbild

Auf den nördlich von Gümüş (bei Gümüşhacıköy) gelegenen Gebirgsrücken befinden sich Hunderte alte Grubeneingänge, Schachtmundlöcher und verstürzte Strecken, als Zeugen einer regen Bergbauaktivität seit gut 5000 Jahren. Dieser über eine Fläche von mehreren Quadratkilometern ausgedehnte Blei-Silber-Bergbaudistrikt gehörte zu den Hauptsilberlieferanten des Osmanischen Reichs. Im Hintergrund ist der Rest einer alten Strecke abgebildet.

Im Vordergrund (oben links) ist die bronzene Sonnenstandart aus Alacahöyük zu sehen. Sie stammt aus den frühbronzezeitlichen Fürstengräbern (ca. 2800-2500 v. Chr.). Zum Grabinventar zählten neben zahlreichen Objekten aus Gold, Silber und Elektron auch bronzene Sonnenstandarte und Tierfiguren.

Weitere Bilder im Vordergrund:

Rechts Oben: In Küre, einer der bedeutendsten Kupferlagerstätten der Türkei, wurde seit der Antike Erz abgebaut.

Rechts Mitte: Auf dem 2400 m über NN gelegenen Sattel von Karadağ (Provinz Gümüşhane) liegen etwa 100.000 Tonnen Kupferschlacken aus Osmanischer Zeit.

Rechts Unten: Aus dem spätbronzezeitlichen Schiffswrack von Uluburun stammen diese Ochsenhaut- und andere Barren. Die Hauptladung des Handelsschiffs bestand aus zehn Tonnen Kupfer und einer Tonne Zinn.

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A. Bernard Knapp & Vasiliki Kassianidou

The Archaeology of Late Bronze Age Copper Production

Politiko *Phorades* on Cyprus

Introduction: Historical and Archaeological Background

An early, 18th century BC cuneiform text from the site of Mari in Syria mentions ‘mountain copper’ from *Alashiya* (T. 361-Sasson, in Knapp 1996: 18), which has been taken as the earliest secure written reference to copper-ore deposits in the Troodos Mountains of Cyprus. Amongst the 14th century BC cuneiform archives found at Amarna in Egypt were nine letters sent from the king of Cyprus (*Alashiya*) to the Egyptian pharaoh (EA 33-40, 114-Moran, in Knapp 1996: 21-25), some of them indicating that copper was produced locally on Cyprus, and in quantities sufficient to merit the attention of merchants and monarchs alike. Whereas five of these letters refer to copper shipments sent from *Alashiya* to Egypt, only three give the actual measure (‘talent’: GUN URUDU - *bilat eré*) whilst the others simply give numbers, assumed now to refer to the actual ingots (see Table 1). Based on analysis of a similar, Hittite inventory text, Zaccagnini (1986: 414) provided more explicit terms and equivalencies of the measures involved. In turn, and after further evaluation of the weights of a ‘talent’ in Bronze Age measuring systems from Babylonia to the Aegean, it can

be argued that the *average* weight of one talent was 28 kg (Alberti & Parise 2005: 382, 389, pl. 83; Knapp 2008: 309-310, tables 5-6). As a group, the Amarna letters from *Alashiya* tabulate 113 ‘talents’ of copper and 934 (ingots) of copper: in today’s terms, this represents over 29,000 kilos of copper.

These and several other, related cuneiform and Egyptian documents (Knapp 2008: 307-313) demonstrate that Cyprus/*Alashiya* was a major copper supplier during the Late Bronze Age (ca. 1650-1100 BC). The mining, production and export of Cypriot copper peaked at this time, an era of settlement growth and unprecedented prosperity on the island. Urban centres with harbours arose all along the Cypriot coast, along with other prominent centres inland (Knapp 1997: 53-63). The wealth of all these sites stemmed from widening trade contacts in the eastern Mediterranean, and the demand for Cypriot copper throughout the Mediterranean world (Muhly *et al.* 1988; Knapp 2008: 357-363).

The copper of Cyprus was traded both commercially and through gift-exchange in oxhide-shaped ingots widely regarded as an internationally accepted unit of trade during the Late Bronze Age (e.g. Muhly *et al.* 1988; Gale 1991; cf. Bass 1967: 71-72). Such ingots have been found throughout the eastern Mediterranean and as far west as Sicily, Sardinia, Corsica, Marseille and now even at Oberwilklingen in Germany (Lo Schiavo 1998; 2003: 23-25; 2005a; 2005b; Primas & Pernicka 1998; Domerque & Rico 2002: 141-144). The Uluburun shipwreck carried over 10 tons of copper in the form of these same oxhide ingots (Pulak 2000: 140), almost all of which are now argued to be consistent with production from Cypriot copper ores (Pulak 2000: 147-150, figs. 14-15; Gale & Stos Gale 2005: 119-124; cf. Hauptmann *et al.* 2002). Because the ship was also carrying a quantity of Cypriot pottery, including lamps and other manifestly unused items (Pulak 1998; 2005: 79-81), Cyprus must have been a major port of call for the Uluburun ship before disaster struck.

This background is well known amongst Mediterranean archaeologists, while the oxhide ingots represent the

Table 1: Copper from *Alashiya* as indicated in the Amarna letters (those in boldface represent the actual measure; other give only a number).

EA 33: 16	200 (ingots) of copper
EA 33: 18	10 talents
EA 34: 18	100 talents
EA 35: 10	500 (ingots) of copper
EA 36: 6	120 +? (ingots) of copper
EA 36: 6, 7	70 and 30 copper (ingots) weighing (one) talent
EA 40: 7	9 (ingots) of copper
EA 40: 13	5 (ingots) of copper
EA 40: 13	3 talents of ‘refined’ copper

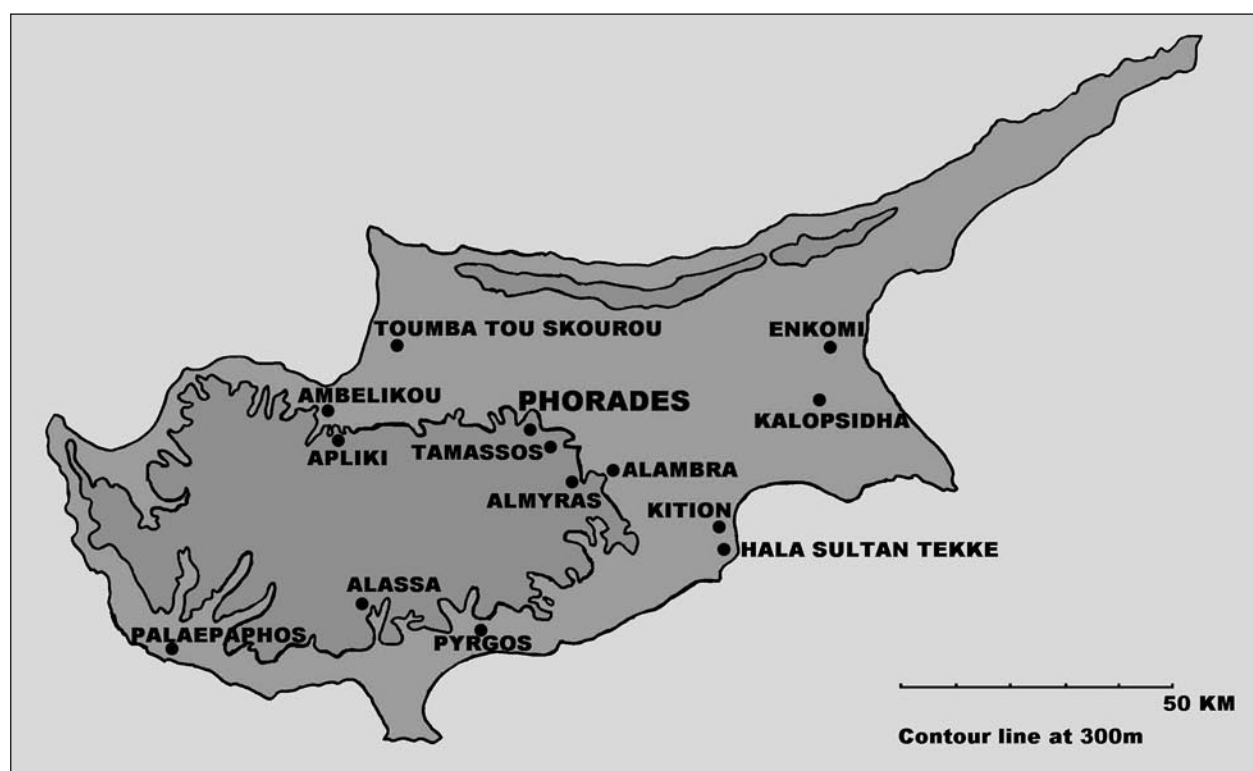


Fig. 1: Map of Cyprus showing the location of Politiko *Phorades* and other key sites of the Late Bronze Age (Vasiliki Kassianidou).

end product of a complex industrial process that involved the mining, smelting and casting of copper (Kassianidou 1999; 2008). Until very recently, however, archaeologists working on Cyprus were concerned chiefly with the finished products of this process: the ingots themselves or the fine weapons, stands and vessels crafted from them (e.g. Catling 1964; Gale 1991; Papasavvas 2001). Some research has treated the spatial scale and social organisation that lay behind the unprecedented levels of economic development during the Late Bronze (e.g. Keswani 1993; 1996; Webb 2002) whilst the overall settlement system has also received attention (e.g. Knapp 1997). Despite all this work, however, almost everything we know about the industrial processes and social practices that lay behind them has been conjectural, or reconstructed on the basis of later evidence. And it must be remembered that almost all Late Bronze Age Cypriot sites that have produced archaeometallurgical evidence are located along the coast or in the agricultural hinterland, not in the metalliferous zones of the Troodos foothills where the primary smelting of copper ores logically would have taken place. Moreover, we know hardly anything from the earliest, Late Cypriot (LC) I levels of all these sites (16th century BC), which are deeply buried - where they exist at all - beneath the often monumental constructions of the LC IIC-III A periods (13th-12th centuries BC).

Muhly (1989: 299), in fact, accurately described the situation that existed until a few short years ago:

"We know very little of any LCI or LC II site save Enkomi, and our knowledge of the Cypriot copper industry during the years ca. 1600-1300 BC comes almost entirely from Dikaios' excavations at Enkomi, with very limited evidence for the MCIII/LC I transition from Kalopsidha."

Prior to that, in the proceedings of the first major international conference on *Early Metallurgy in Cyprus*, Weisgerber (1982: 29-30) had observed:

"To get detailed informations [sic] of mining and smelting antiquities these first have to be studied in small one-period sites. I am rather sure that these either are known or still can be found on Cyprus, by extensive survey and also by looking at river banks."

Prophetic words: the excavations at Politiko *Phorades* have now demonstrated the accuracy of Weisgerber's prediction, and at the same time expanded our knowledge of the earliest phases of Late Bronze Age copper production on Cyprus in a way that Muhly might never have imagined. Let us now consider the story of the *Phorades* project from its beginning.

Excavations at Politiko *Phorades* (Fig. 1)

Copper-bearing ore deposits in the Troodos Mountains that occupy most of central and western Cyprus have



Fig. 2: Modern spoil heap, *Kokkinopezoula* mine near Mitsero: interior view (Bernard Knapp).

been worked repeatedly over the past four thousand years (Constantinou 1992). In order for a Bronze Age producer to reach, exploit and transport copper from ore deposits spread along the flanks of the Troodos Mountains, somebody had to construct facilities for smelting, develop roads for transport, and establish and maintain communications between these production zones and the coastal towns from which refined copper ores were exported (Peltenburg 1996). As we worked at *Phorades*, we sought to keep these larger issues in mind. For example, how would Bronze Age people have interacted with their landscape? Mining, even on a small, local scale, can have a major impact on the landscape, and on the relationship between people and their environment. In the modern village of Mitsero, for example, the massive spoil heap of *Kokkinopezoula* (Fig. 2) dominates the surrounding fields and serves as a clear case of how these villagers had to cope with a dramatically altered landscape, redefine their village, and develop a new sense of identity in order to live and survive in that very landscape.

During the course of the Sydney Cyprus Survey Project (Given & Knapp 2003), when we lived in that same village of Mitsero, our geomorphologist Jay Noller observed a large quantity of slag and furnace material

eroding out of the bank of a dry creek bed, enough cultural material to make him suspect the presence of an industrial installation. Shortly thereafter one of us (VK, the project's archaeometallurgist) visited the newly-discovered 'site' and realised immediately that both the slag and the furnace lining were unique and unprecedented in their shape and technology. That site, now

Fig. 3: The site of Politiko *Phorades* during excavation (Vasiliki Kassianidou).





Fig 4: The stone lined cavity (indicated with black arrow) and tuyères (indicated with white arrows) from Politiko *Phorades* (Paul Duffy).

designated Politiko *Phorades* (Fig. 3), was excavated over three field seasons (1997, 1998, 2000) and proved to be a small copper-smelting workshop. Radiocarbon dates, well-stratified pottery, and the geological setting all place *Phorades* in an early phase of the Late Bronze Age (ca. 1650-1500 BC) (Knapp *et al.* 2009).

Paleoenvironmental analysis, including detailed geomorphological mapping and stratigraphic study of soils and sediments, revealed an approximately 15,000-year record of environmental change in the Kouphos River valley, where *Phorades* is situated (Noller, in Knapp *et al.* 2009). Because the site is situated in an active depositional environment, its stratigraphy proved to be very complex, but geomorphological input helped us to untangle the differing natural and anthropogenic forces that resulted in the site's formation. The excavations indicate that the metalworkers used river channel deposits to construct an artificial bank, a flat working platform on which they operated the smelting furnaces (a patch of fired clay discovered on this surface suggests it was indeed once a working floor). Within this artificial bank we uncovered a stone-lined cavity, within which were several tuyère fragments, and around which were several almost complete tuyères (Fig. 4). This cavity is not a smelting furnace (which consisted of cylinders made entirely of clay and placed on a flat surface) but it may have been related to the smelting process, e.g. a tapping pit. The slag produced in the smelting process was piled against the creek's bank, and eventually formed a small slag heap (Fig. 5). Just east of the slag heap we found a concentration of furnace wall fragments as well as a unique, quite well preserved elbow tuyère.

Beyond a couple of possible crushing stones, we found no other evidence of ore beneficiation or the actual roasting process. Either these steps took place in some part of the site since eroded away, or else they occurred nearer the actual mine. The likeliest source of the ores smelted at *Phorades* is located at a nearby hill called Kokkinorotsos, about 500 m. to the northwest and visible

from the site because of its brightly coloured gossan. The creek - which once ran alongside the smelter but through incision and erosion processes has changed its course and now lies below it - eroded the slag heap and incorporated much of it in alluvial deposits that eventually buried most of the smelting workshop. Thus most of the original land surface has been lost, as has much of the workshop itself. It is worth noting that in the excavated area a significant amount of gossan nodules were found and collected; these must have been brought intentionally from Kokkinorotsos to the workshop. In this area of the Troodos Pillow Lavas, apart from limonite, the gossans also contain varying amounts of hematite, jarosite, native sulphur and white friable silica (Bear 1960: 89). The gossan may have been collected specifically because of the silica, which could have been used as a flux in the smelting furnaces at *Phorades*.

Any interpretation of this complex site must take into account the geomorphological factors noted above. As we understand the site, *Phorades* displays a careful ordering of space in relation to waste deposition. While this may be viewed as a necessity in any activity that produces large quantities of waste, such was not always the case with prehistoric technologies. The material from *Phorades* also portrays the activities that once occurred at the site. The concentrations of broken tuyères and furnace fragments, and the large quantities of slag which - given its weight - is unlikely to have been transported far, all indicate that the smelting operation took place at *Phorades* itself. In comparison to the metallurgical remains, other archaeological finds such as pottery, chipped stone and groundstone tools, and even metal tools are few in number or completely absent. *Phorades* was a smelting workshop: once it was abandoned such things as were left behind (i.e. the slag and the broken installations) no longer had any use. Other artefacts that could be curated and used again, elsewhere - such as diabase pestles, the mortars used to prepare the ores, the metal tools and the pottery - were all removed once the operation shut down.

Fig. 5: The slag heap at Politiko *Phorades*, during excavations (Vasiliki Kassianidou).



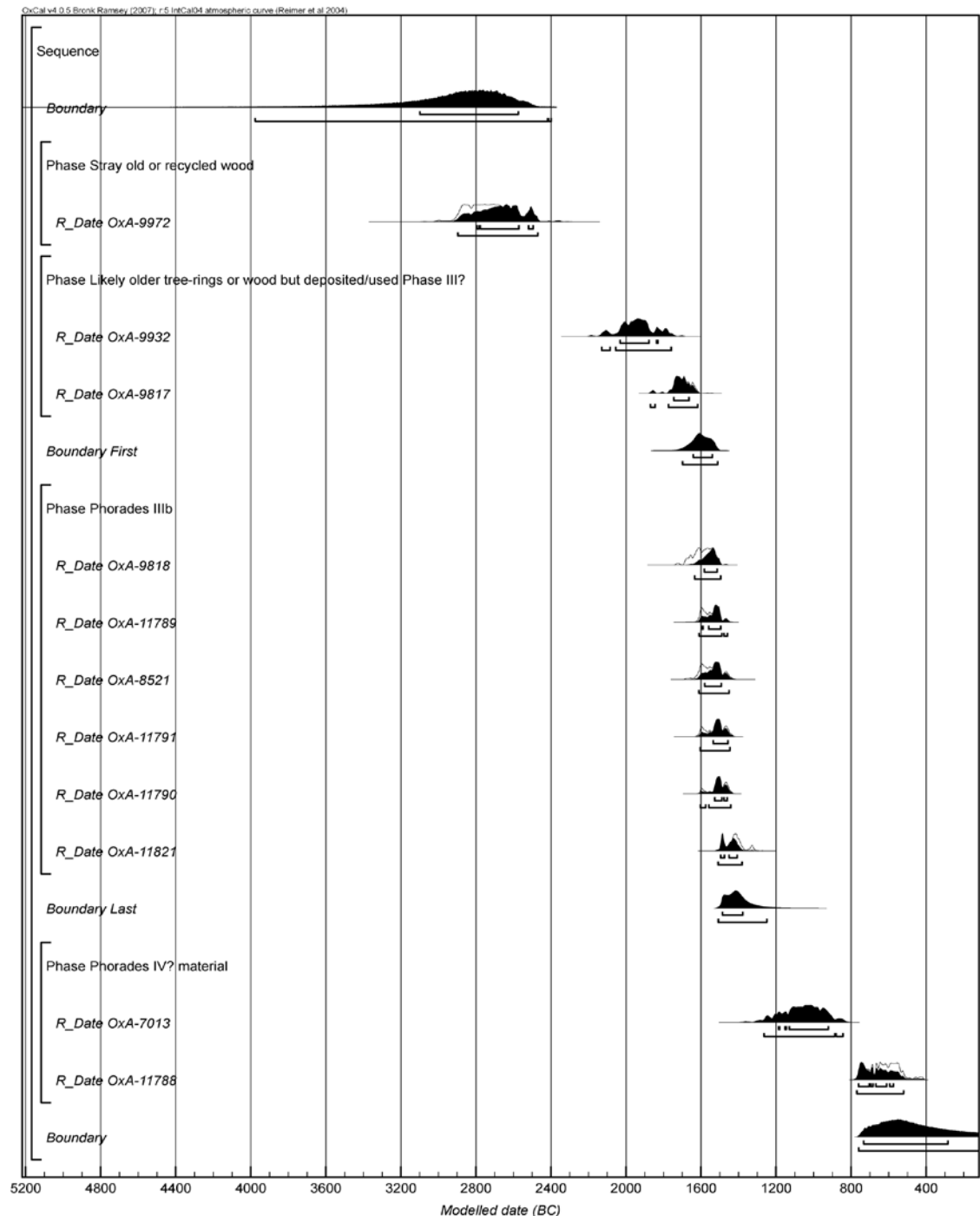


Fig. 6: The calibrated calendar ages of the radiocarbon dates from Politiko *Phorades* shown in a subjective interpretation analysis. The upper and lower horizontal lines under each probability distribution indicate the 1 σ (68.2 % confidence) and 2 σ (95.4 % confidence) calibrated calendar age ranges respectively (modelled). The Phase III grouping is stratigraphically defined. The assessments of the earlier phases, however, represent entirely subjective judgements made on common-sense grounds: the first is a stray/old/recycled sample of no apparent relevance (OxA-9972); the second comprises two samples considered as perhaps older, i.e. inner, tree-rings or old wood now used or recycled in the Late Bronze Age (OxA-9932 and OxA-9817). This is also the case for a more recent post-Phase III, perhaps Phase IV, grouping (stratigraphy notwithstanding) of what is substantially more recent material (OxA-7013 and OxA-11788). The main Phase III grouping of six dates forms a clear and fairly tight chronological grouping (compared to the other data before and after). This grouping best reflects the age of pieces of wood/charcoal employed at the site in Phase III activities. All samples are charcoal (*Pinus brutia* where known – this species grows around the site area today) and so represent *terminus post quem* estimates for actual human use. The Phase III data grouping lies between 1630-1386 BC *un-modelled* (the hollow histograms in the figure) at 1 σ (68.2 % confidence) and between 1597-1408 BC when modelled (the solid histograms in the figure – employing the model indicated) also at 1 σ . Thus we are observing and dating activity at the site during the 16th-15th centuries BC (and at the latest early 14th century BC, even allowing for the *terminus post quem* issue). The period of time likely represented as describing the overall spread of calendar time in the Phase III grouping – that is the time between the Boundary 'First' and the Boundary 'Last' in the Figure – is 90 to 275 years at 1 σ and 15 to 405 years at 2 σ . Calibration employs OxCal 4 (Bronk Ramsey 1995; 2001 and versions since), using IntCal04 (Reimer *et al.* 2004) with curve resolution set at 5 (Sturt W. Manning).

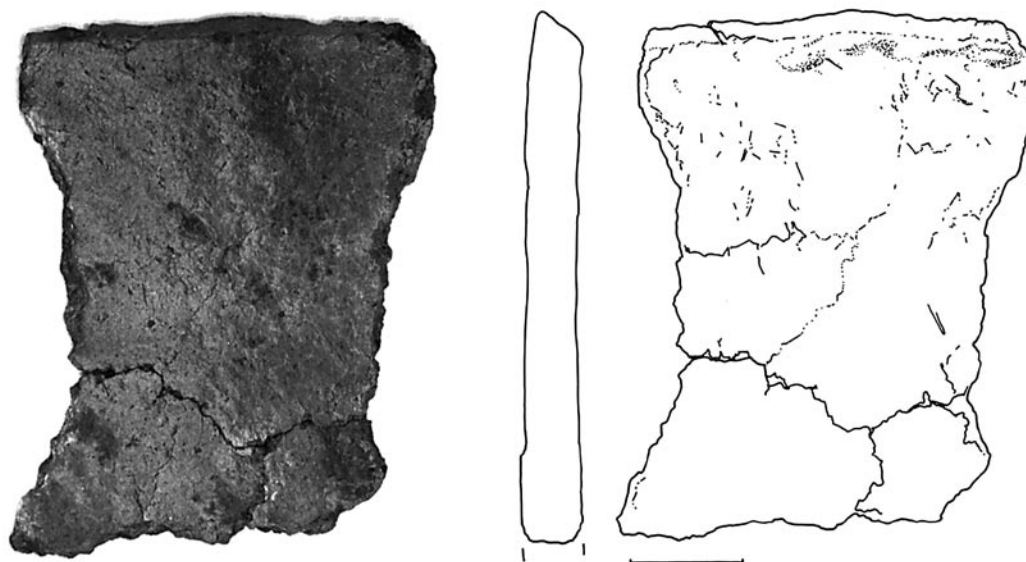


Fig. 7: Furnace wall fragment from Politiko *Phorades* (photograph: Christopher Parks; drawing: Glynnis Fawkes).

The small number of pottery sherds we found provokes interesting questions about the activities associated with smelting operations and the status of copper workers within Cypriot Bronze Age society. Much of it is typical, fine ware pottery - White Slip I and II [early], Base Ring I, Red Lustrous Wheel made, Black or Red Slip Wheel made - and was found almost exclusively within the site's well-stratified metalworking levels. The dearth of coarse, utilitarian wares (a single sherd of Plain White Handmade ware and another from a pithoid jar or large basin) and the presence of all these fine wares suggest that somebody at *Phorades* had access to what we usually regard as higher-status goods, more typically seen in funerary contexts. Intensive survey in this area, however, revealed no evidence whatsoever of mortuary deposits of any period (Given & Knapp 2003: 130-146), and the sherds themselves show no evidence of being worn by water transport. On the contrary some of them show signs of having been in long-term contact with copper slag: we have therefore reached the conclusion that these sherds were deposited originally and contemporaneously with the slags.

Although the very tight dating of all this pottery demonstrates a LC I-early LC II date of deposition, we also carried out a series of radiocarbon analyses on charcoal found within the furnace walls and the slag (Manning, in Knapp *et al.* 2009). The samples analysed, all employing the AMS technique at the Oxford Radiocarbon Accelerator Unit (Fig. 6), demonstrate clearly a calendar age range somewhere in the 16th-15th centuries BC, fully consistent with the pottery assemblage from *Phorades*.

If the site itself will never make its way onto UNESCO's list of world heritage sites, the same cannot be said of its archaeometallurgical remains (Kassianidou, in Knapp

et al. 2009). During the excavation, we collected over 6000 fragments of furnace rims, walls and bases, all produced from coarse clay mixed with large amounts of chaff or other organic materials (Hein *et al.* 2007: 146-147). Unfortunately, it was not possible to reconstruct a furnace in its entirety, and thus the height of the installation remains unknown. Some of the largest fragments, however, indicate that they would have been at least 30 cm high with an estimated diameter of approximately 42-44 cm (Fig. 7). The thickness of the furnace walls ranges between 2,5-4,5 cm, while the thickness of the bases ranges between 4-7,5 cm. Fingerprint impressions on the exterior, usually where the wall joins the base, show how the furnaces were constructed: a thick, flat, circular disk was formed on which the cylindrical body was built with slabs (Fig. 8). It is clear that the furnaces were constructed in the round, not in a pit or against a stone wall. Had the latter been the case, the outer surface would not have been so smooth and finger impressions would have been found on the interior surface where the maker would have pushed the clay against the pit or the

Fig. 8: Furnace base fragment from Politiko *Phorades* (Glynnis Fawkes).



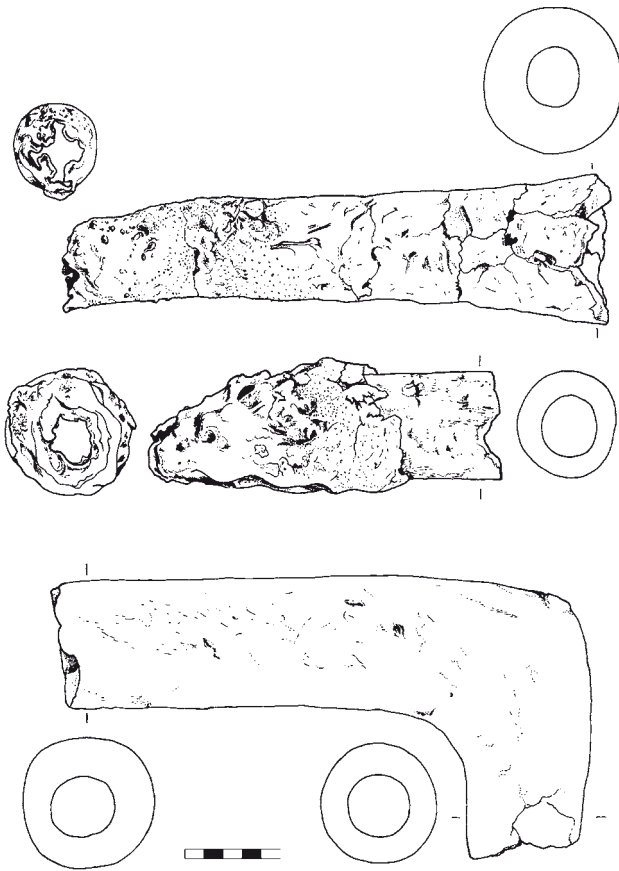


Fig. 9: Three types of tuyères found at Politiko *Phorades*: cylindrical, double-walled and elbow (Glynnis Fawkes).

stone structure (as was the case at Timna: Rothenberg 1990: 12 and fig. 25, and at Ayia Varvara *Almyras*: Fasnacht *et al.* 1992: 63 and plate 17.1).

The best parallel for the *Phorades* furnaces is the well-known 'crucible' from Enkomi (Dikaios 1969: 58; Dikaios 1971: 644; Inventory no. 1640), which Tylecote (1982: 92) defined as a smelting furnace. This 'crucible' was

recovered from the floor of what is defined as a copper workshop and was dated to the 13th century BC (Dikaios 1971: 452). It is, therefore, later in date than the furnace fragments from *Phorades*, and it is also smaller in size, with a diameter of about 30 cm. and a preserved length of 20 cm. The Enkomi example may thus have had a different function, perhaps for use in melting processes. Because similar fragments of such refractories have also been found at Kition (Stech *et al.*, in Karageorghis 1985: 391-393), we may conclude for the time being that this was the standard type of furnace used on Late Bronze Age Cyprus. As no smelting furnaces have yet been found dating to the Middle Cypriot period, the well-preserved examples from *Phorades* remain the earliest known smelting furnaces on Cyprus.

Turning to the tuyères, once again we quote a passage from Muhly's (1989: 299) paper on the organisation of the Late Bronze Age copper industry on Cyprus:

"I have gone through roughly one-tenth of all the trays from Enkomi.... From these, I have catalogued some 400 fragments of tuyères or blow pipes. I know of no other Bronze Age site in the Mediterranean that has produced more than half-a-dozen such objects."

At *Phorades*, in an excavated area of approximate 30 sq m, we have recovered 50 almost complete tuyères and up to 600 tuyère fragments. Most of the tuyères are cylindrical although (as noted above) a single elbow tuyère was found as well as a small group of rather intriguing double-walled tuyères (Fig. 9). As is the case with the furnaces, the dimensions of the tuyères conform to a certain standard: the outer diameter ranges between 5-7 cm and that of the airhole, which is rarely perfectly cylindrical, or symmetrically positioned, ranges between 2,5-3,5 cm. None of the tuyères is fully preserved but one of the best examples has a length of about 30 cm (see Figs. 9, 10). Where the nozzle is preserved, it is highly vitrified and slagged (Figs. 10, 11). The tuyères from *Phorades* are quite similar in shape and material

Fig. 10: Cylindrical slagged tuyères from Politiko *Phorades* (Christopher Parks).



Fig. 11: Two double-walled tuyères from Politiko *Phorades* (Christopher Parks).



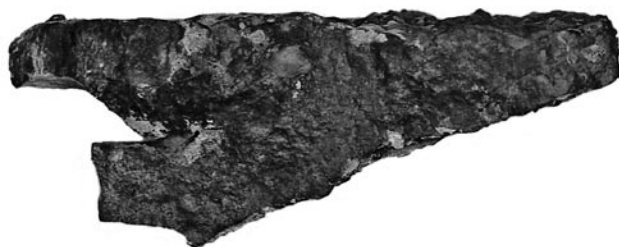


Fig. 12: Edge fragment of a slag cake from Politiko *Phorades* (Christopher Parks).

to those from Enkomi and Apliki as well as other Late Cypriot tuyères (Tylecote 1982: 92-93, fig. 7) classified Cypriot tuyères into three categories: straight cylindrical, straight 'D'-shaped and elbow. Unique to *Phorades* and previously unknown on Cyprus, however, are four well-preserved double walled tuyères. These were formed when a new layer of clay was wrapped around what appears to be a used tuyère, identified as such because of its slagged outer surface (Fig. 11). Unlike the double tuyères from New Kingdom Timna, where the inner tuyère was protected by a second layer made of more refractory clay (Rothenberg 1990: 8), the *Phorades* examples must represent repair work. The size and shape of these tuyères (the double-walled tuyères are quite wide) provide clues to their position within the smelting furnace. Unlike the proposed reconstruction of furnaces from Kition, with the tuyère introduced from the side (Tylecote 1982: 91, fig. 4), the furnaces from *Phorades* show no curvatures or holes that could accommodate such wide tuyères. It is therefore probable that the tuyères were set in place in the top of the furnaces; the extent of slagging in most of the tuyères suggests the same. Such a setup would have been facilitated with the help of a raised platform on one side of the furnace, not unlike the platform we excavated at *Phorades*.

A detailed chemical and mineralogical study of the furnaces and tuyères (Hein & Kilikoglou 2007; Hein *et al.* 2007; Hein & Kilikoglou, in Knapp *et al.* 2009), as well as the petrographic analysis undertaken by Xenophonotos (in Knapp *et al.* 2009), revealed that local clay deposits were used for their manufacture, and were specifically chosen because they contained significant amounts of non-plastic rock fragments. As a result the heat resistance of the ceramic bodies was significantly increased and enabled the installations to withstand temperatures up to 1200 °C. These studies also demonstrated that the standardisation noticed in the shapes and dimensions of the furnaces and tuyères was also evident in the selection of raw materials, clay processing and moulding.

Egyptian wall paintings as well as material from excavations at Alassa and Enkomi demonstrate that, at least

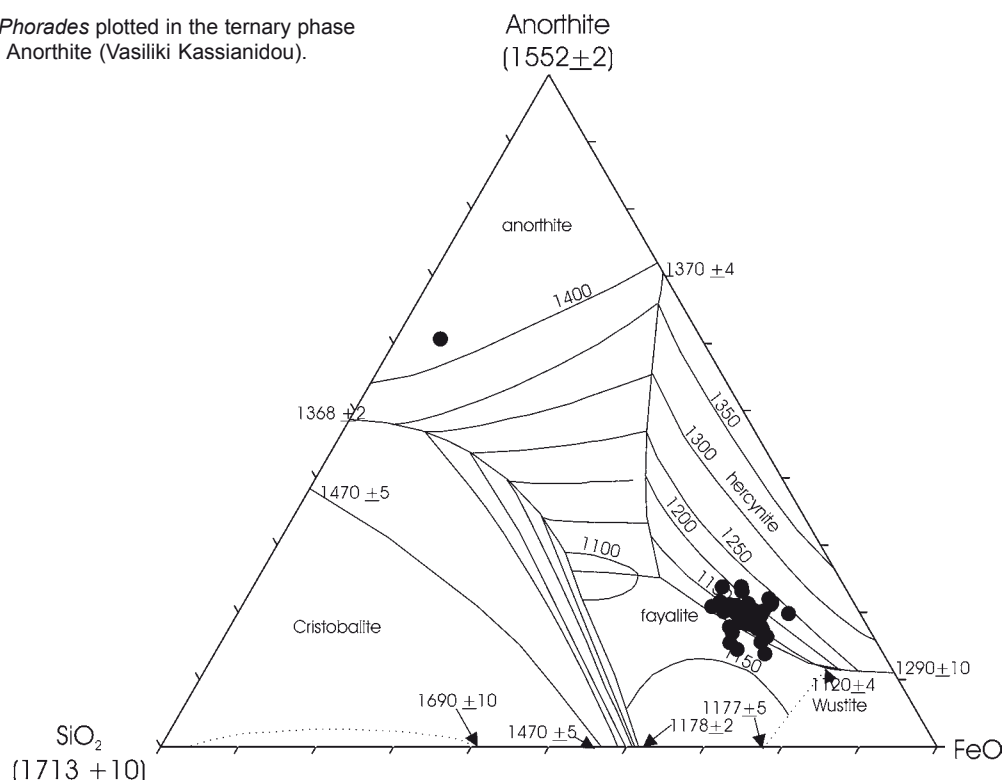


Fig. 13: Base fragment of a slag cake from Politiko *Phorades* (Christopher Parks).

later in the Bronze Age, ceramic bellows were used in conjunction with tuyères (Tylecote 1981). But we found no evidence of bellows (apart from two very coarsely made sherds that had been exposed to very high temperatures). Of course it is possible that bellows were made from organic materials, such as leather. We do know that the ore smelted in the furnace was a copper sulphide and, thanks to the painstaking efforts of Maria Ntinou (in Knapp *et al.* 2009), that the fuel used was almost exclusively charcoal produced from *pinus brutia*, a tree that dominates the landscape today and, more importantly, one that thrives even in the lunar landscapes wrought by my most modern industrial mining operations.

Slag, of course, is the most prominent waste product of the smelting process, and it forms by far the most abundant, not to say heaviest find from the excavations at *Phorades*. We collected over 3.5 tons of slag fragments that derive from large plano-concave cakes: each had an estimated diameter of about 44 cm. at the top and weighed approximately 20 kg. All diagnostic pieces have a well-defined edge that angles inward towards a concave base (Figs. 12-13). The slag is homogeneous, very dense and magnetic, the result of high percentages of

Fig. 14: Slag from Politiko *Phorades* plotted in the ternary phase diagram of FeO, SiO₂ and Anorthite (Vasiliki Kassianidou).



iron oxides which was identified during bulk chemical analysis (using XRF, undertaken by Andreas Karydas of NCSR Demokritos in Athens). When the analytical data are plotted in a ternary phase diagram for FeO-SiO₂ and the mineral anorthite, suggested by Bachmann (1982: 11) to be appropriate for copper smelting slags with a low calcium concentration, they fall well within the area of fayalite (Fig. 14) (Kassianidou, in Knapp *et al.* 2009). The average chemical composition of the analysed slag samples from *Phorades* is presented in Table 2. Microanalysis showed that the main mineral phases in the slag are indeed fayalite and wüstite, which are embedded in a small quantity of glassy matrix (Fig. 15) (Kassianidou, in Knapp *et al.* 2009).

Although, in section, no metallic prills are visible to the naked eye, the copper content of the slag averages 2,7 %, relatively high in comparison to that of slag dating to later periods. In the Roman period, for example, copper concentrations are below 1 % (Kassianidou 2004: 100). Microanalysis also showed that the copper is present in the form of matte prills (Fig. 16). Full analyses of the slag are presented in our final monograph (Kassianidou, in Knapp *et al.* 2009).

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CoO	TiO ₂	MnO ₂	K ₂ O	P ₂ O ₅	CuO	ZnO	S
23.9	4.8	64.4	1.8	0.4	0.1	0.2	0.3	2.7	0.4	1.2

Table 2: Average values of chemical composition of slag from *Phorades* determined by XRF and given in weight %.

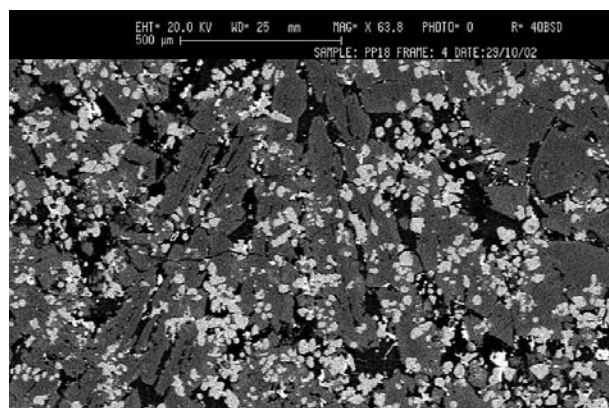


Fig. 15: Micrograph of slag sample from Politiko *Phorades* showing fayalite crystals and iron oxide dendrites (Vasiliki Kassianidou).

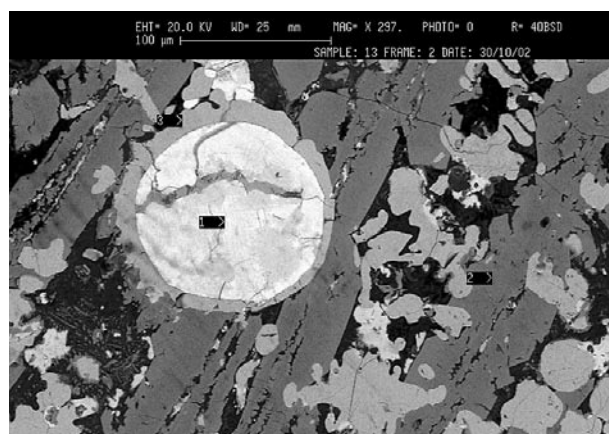


Fig. 16: Micrograph of slag sample from Politiko *Phorades*, showing a matte prill (Vasiliki Kassianidou).

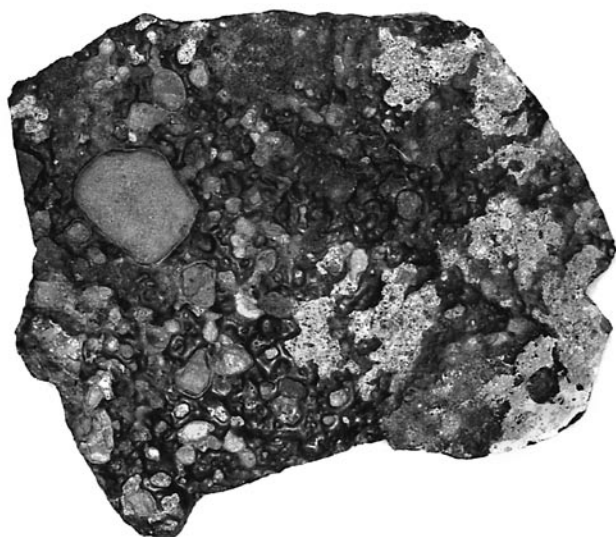


Fig. 17: Edge fragment of a slag cake with fine pebbles embedded in the outer surface (Christopher Parks).

What can these unique slags tell us about production practices at *Phorades*? The concave bottom suggests that the slag cakes cooled on top of a layer of molten metal. Microscopic analysis shows that this metallic phase was matte, not copper, and long fayalite crystals indicate that the slag cooled rather slowly. But was the slag cooled in the furnace? Careful work on the slags indicates not. A number of the cakes have small river pebbles embedded in their edges (Fig. 17), but such pebbles have never been found in the furnace walls or lining. Thus it seems likely that the contents of the furnaces were tapped into a pit (perhaps like the stone-lined feature mentioned above), occasionally filled with fine pebbles. Bamberger and Wincierz (1990: 133), whose experimental smelting experiments produced an almost identical slag by following a technique described by Agricola (*De Re Metallica* IX: 404-407), showed that such an operation is possible.

The slags from *Phorades* differ in type and shape from all other known Late Bronze slags that have been excavated on Cyprus, for example the large tap slags from Apliki (Muhly 1989: 306) or the plano-convex slags from Kition (Tylecote 1982: 89), both later in date by at least 300 years. Moreover, they are completely unlike the slags, small and nodular in shape, from the Middle Bronze Age site of Alambra (Gale *et al.*, in Coleman *et al.* 1996: 389-390, 414, tables 2.15, 2.16), which is at least 200 years earlier. And they are quite different from the slags found at Pyrgos *Mavrorakhi* (Belgiorno 2004: 31; Giardino 2000: 21), which the excavator, at least, would date to about 1900 BC, some 300 years earlier than *Phorades* (Belgiorno 1999; 2004: 21). Because the bulk of the pottery from Mavroraki dates to a late phase of PreBA 2, and because the association between its archaeometallurgical finds and its structural and ceram-

ic elements is uncertain (Muhly 2002: 81), it seems premature to discuss the role and function of this crucial site in Cyprus's early metallurgical history (cf. Keswani 2005: 386-387). In any case, the slag from *Phorades* is clearly the product of a much more advanced smelting technology than that of the Middle Cypriot period, one which used tuyères to raise the temperature, which in turn allowed a better separation of the slag and metal phases (Kassianidou 2007).

The metal produced in the smelter at *Phorades* was matte, which was determined not only by the presence of matte prills within the slag matrix, but also by the discovery of a small piece of matte, silver-blue in colour: it consisted of 73,5 % copper, 2,6 % iron and 23,9 % sulphur. As an intermediate product in the production of copper metal, matte has always proved to be quite rare; its presence at *Phorades* is yet another indicator that this was a primary smelting workshop. In order to produce copper, matte had to go through a series of other processes, each of which would produce a different type of slag. With the exception of one sample (which contained black copper as well as matte) among all those analysed, all others fall within the category of primary smelting slags. In other words, it is only this initial stage in the process that took place at the *Phorades* workshop. Evidence from the large coastal towns of Late Bronze Age Cyprus indicates that secondary smelting and refining processes were carried out there, where standardised (oxide) ingots would have been produced for distribution and consumption, both internal and external. *Phorades*, in other words, was a primary smelting workshop, small in size but large in importance, as it has allowed us to reconstruct the smelting technology of the mid-second millennium BC.

Discussion and Conclusion

Do the excavations at *Phorades* help us to understand better how mining and metallurgy affected the Bronze Age metalsmiths, farmers and communities of Cyprus? The level of production at *Phorades* is not of a magnitude (estimated at about 350 kilos) to suggest a major island-wide operation under centralised control. Rather it indicates a localised manufacture of copper, perhaps with some surplus entering a network where metal was traded for pottery and other goods. If that was the case, then metalsmiths within Cypriot society may have held some notable status within the wider trading network. This system almost certainly changed in the latter part of the Late Bronze Age (Late Cypriot 2) to one of specialised craftsmen working for elites in the town centres.

The activities indicated by the *Phorades* excavations were preserved only as the result of a very particular set of erosional and depositional factors. Many other

sites of similar size and nature must have existed in the Pillow Lavas of the Troodos but have been lost as the result of various post-depositional factors, especially modern-day mining (Bruce 1937). The recovery of material associated with some stage of copper smelting is not uncommon in the rural sites of prehistoric Cyprus (e.g. Athienou: Maddin *et al.* in Dothan & Ben-Tor 1983: 132-138), and one major implication of the excavations at *Phorades* is that we must now reconsider the overall economic constellation of Late Cypriot mining and production sites, agricultural villages, rural sanctuaries, inland towns and the coastal distribution centres, all set within their community context.

An archaeology of community (Canuto & Yaeger 2000; Gerritsen 2003), in particular the concept of an imagined community (Anderson 1991; Isbell 2000), enables us to situate *Phorades* more firmly in its regional context and in the wider, Late Bronze Age landscape of Cyprus. *Phorades* and whatever agricultural support village may have supported it formed part of a broader, regional community, perhaps a harbinger of the Iron Age town and kingdom of Tamassos, whose remains are located on the western perimeter of the modern village of Politiko. The site of Aredhiou *Vouppes*, some three kms distant, remains the nearest-known agricultural support village (Given & Knapp 2003: 179-182; Steel & Janes 2005; Steel 2007). No previous archaeological investigations, however, have uncovered evidence for a Late Bronze Age town centre in the Politiko area. Intensive survey by SCSP revealed a veneer of Late Bronze Age pottery spread across the broad plains immediately to the west and north of Politiko (Given & Knapp 2003: colour plate 47), which may well indicate the manuring of fields surrounding a still undiscovered 'site' in this region. There are, moreover, some notably rich tombs of Middle-Late Bronze Age date around Politiko village (Middle Bronze tombs at *Lambertis* and *Chomazoudhia*; some Late Bronze Age remains at Politiko *Ayios Iraklithios* Tomb 6) (Masson 1964; Karageorghis 1965; Given & Knapp 2003: 268). Site and settlement patterning in and around this sector of the SCSP area thus suggests that a larger polity, the focus of the proposed broader regional community, may lie very near if not beneath the modern village of Politiko.

An archaeology of community enables us to suggest that, at *Phorades* itself, the shared mentality which structured the metalworkers' perceptions and actions were situated within a socially distinct 'imagined community'. In turn, this local 'imagined community' was embedded within the wider regional community (in SCSP terms, Special Interest Area 7: Given & Knapp 2003: 130-146; Knapp 2003) with all its attendant agricultural and industrial practices of affiliation. This regional community was clearly more complex, spatially extensive and multi-functional than the individual, more local communities nested within it.

Industrial sites like *Phorades* fulfilled the regional community's basic needs for raw materials and certain finished products. But when external demand accelerated the production of copper beyond local or regional capacities, as seems to have been the case during the successive phases of the Late Bronze Age on Cyprus, mining sites and their community networks soon became integrated into much greater, inter-regional trading networks. These developments brought exotic goods, migrant labour and new ideologies into the mining region, all of which led to new social uses of space as well as socio-structural changes within the regional community. All these factors lay behind the unprecedented technological and social developments that propelled Cyprus into the position of an urbanised, state power, a major purveyor of copper to the Bronze Age Mediterranean world.

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