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EARLY BRONZE AGE METAL TRADE IN THE EASTERN MEDITERRANEAN. NEW COMPOSITIONAL AND LEAD ISOTOPE EVIDENCE FROM CYPRUS

Summary. *This paper presents the results of chemical and lead isotope analyses of 17 Early and Middle Bronze Age artefacts from Cyprus. These suggest that a number of objects are of non-Cypriot copper and lead to the identification of several as imports, a new explanation for some artefact types as ingots and a discussion of the nature of deposits at the key Cypriot site of Vasilia. This in turn allows a reconsideration of the role of Cyprus in an Aegean/eastern Mediterranean metals trade in the early years of the second half of the third millennium BC and of the development of metalworking on the island.*

ARTEFACT DESCRIPTION AND PROVENANCE (JMW AND DF)

In 1985 Dr Stuart Swiny collected samples from 17 Bronze Age metal artefacts from Cyprus now in the Museum of Antiquities of the University of New England (Armidale, Australia) (hereafter UNEMA) (Table 1, Fig. 1). Ten of these formed part of the private collection of the late Professor J.R.B. Stewart. They were acquired by the UNEMA through the good offices of his widow, Mrs D.E. Stewart, in 1974 and 1978. The remaining seven items were salvaged or excavated by Stewart from Early Cypriot (hereafter EC) and Middle Cypriot (hereafter MC) Bronze Age tombs at Pano Dikomo *Mavro Nero*, Bellapais *Vounous* and Karmi *Palealona* in northern Cyprus in 1937, 1938 and 1960 (Fig. 2). They were held by the Nicholson Museum at the University of Sydney before entering the UNEMA in 1972, 1974 and 1978 (Webb 1997, 58). The objects sampled are listed in Balthazar 1990, 69, Table 59, where they are all said to come from Stewart's excavations.

The seven excavated items are dated by associated pottery to EC I (nos. 7, 15), EC III (nos. 10, 16–17) and EC III or MC I (nos. 12–13). In addition, axe no. 6, said to be from Deneia, and knife no. 11, reportedly from Bellapais *Vounous*, may also be placed typologically within EC III or MC I–II.

The eight remaining objects comprise two axes with polygonal butts (nos. 1–2), an axe with domed perforated butt (no. 5), a spearhead (no. 4), a sword with bent blade (no. 8), an armband or ring-ingot (no. 3) and two knives (nos. 9, 14). They belong to a group of nine metal artefacts, seven pottery vessels and a pottery lid acquired by Stewart from the Nicosia dealer Petros Colocassides on 8th December, 1959 (Webb 1997, 71–5, nos. 327–43). The ninth metal

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TABLE 1
Seventeen artefacts in the UNEMA sampled for compositional and lead isotope analysis

Sample	Artefact	LxW (cm)	Wt (g)	Provenance	UNEMA	Publication	Date
1	axe	19.3 × 4.3	342.7	Vasilia?	74/6/2	Webb 1997, no. 330	Philia EC
2	axe	21.8 × 5	333.5	Vasilia?	74/6/0	Webb 1997, no. 328	Philia EC
3	ring-ingot	11 × 11.9	443.6	Vasilia?	74/5/1	Webb 1997, no. 327	Philia EC
4	spearhead	33.2 × 3.5+	305.4	Vasilia?	74/6/4	Webb 1997, no. 332	Philia EC
5	perforated axe	17.5 × 5.5	592.3	Vasilia?	74/6/3	Webb 1997, no. 331	Philia EC
6	perforated axe	18.5 × 5.9	945.7	Deneia?	78/160/1	Webb 1997, no. 344	EC III/MC I–II
7	axe	8.8 × 4.3	98.6	Bellapais *Vounous* T 96.9	74/19/1	Stewart & Stewart 1950, 105, pl. CVIIc	EC I
8	sword	54 × 4.1+	217.1	Vasilia?	74/6/5	Webb 1997, no. 333	Philia EC
9	knife	16.1 × 3.2	44.5	Vasilia?	74/6/6	Webb 1997, no. 334	Philia EC
10	knife	13.2 × 3.2	27.6	Bellapais *Vounous* T 148.8	74/20/2	Stewart & Stewart 1950, 349, pl. CIVb	EC III
11	knife	13.5 × 2.4	31.3	Bellapais *Vounous*?	78/141/1	Webb 1997, no. 361	EC III/MC I–II
12	knife	11.5 × 2.4	18.4	Karmi *Palealona* T 2.18	72/03/18	unpublished	EC III/MC I
13	knife	13.1 × 3.2	31.3	Karmi *Palealona* T 2.19	72/03/19	unpublished	EC III/MC I
14	knife	10 × 2	12.3	Vasilia?	74/6/7	Webb 1997, no. 335	Philia EC
15	razor	11.8 × 3.7	18.9	Bellapais *Vounous* T 112.5	74/21/1	Stewart & Stewart 1950, 147, pl. CVIb	EC I
16	razor	8.3 × 3	11.3	Bellapais *Vounous* T 148.6	74/20/1	Stewart & Stewart 1950, 349, pl. CVIc	EC III
17	pin	13.8 × 0.6	11.4	Pano Dikomo *Mavro Nero* T A.13	78/142/1	Webb 1997, no. 367	

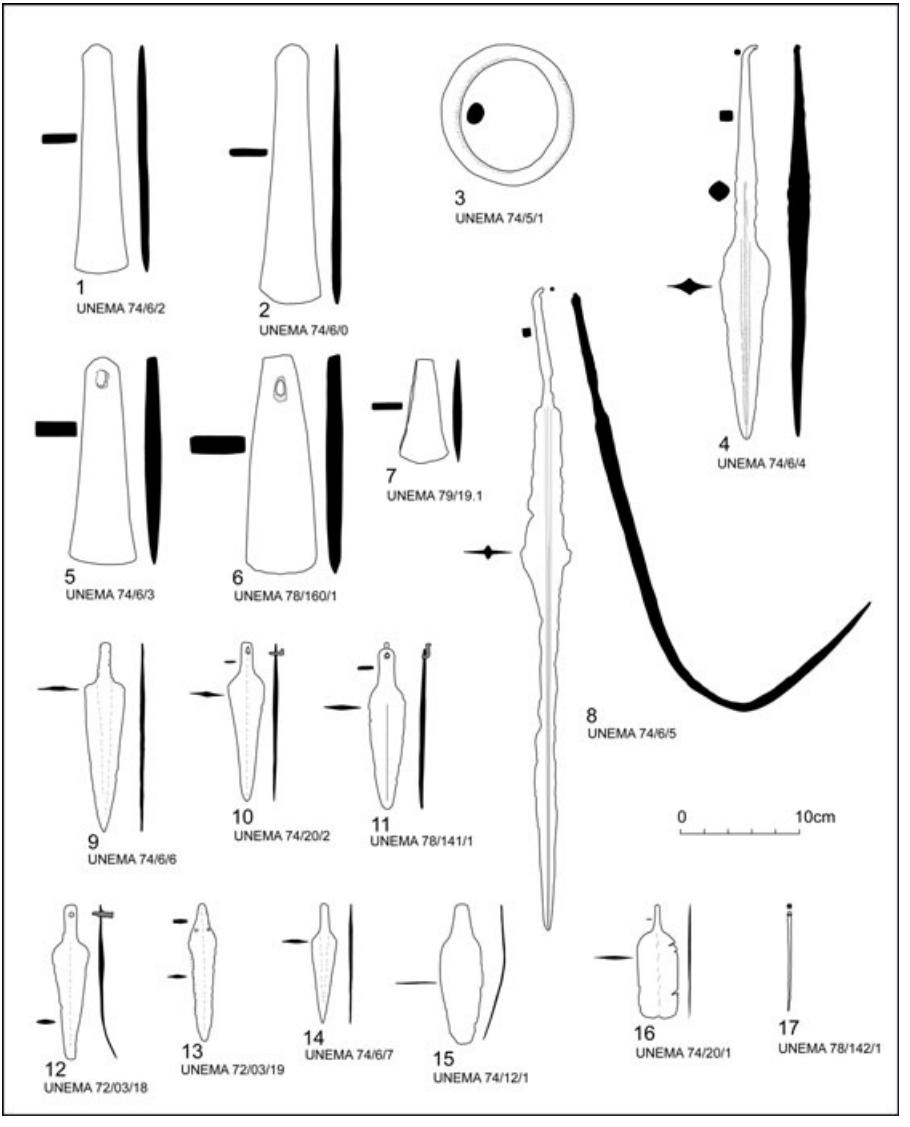

Figure 1
Early and Middle Cypriot Bronze Age metal artefacts in the University of New England Museum of Antiquities sampled in this study (drawn by J.M. Webb and D. Frankel).

object, another axe with polygonal butt, was not sampled. They form part of a larger set of 26 objects (13 metal, 11 ceramic and two stone) offered for sale at that time. Colocassides did not disclose the provenance of this material but Stewart was of the strong belief that the metal items formed a single deposit and came from a looted tomb at Vasilia on the north coast. The Vasilia tombs, which were being looted at this time, belong to the Philia facies, a distinctive archaeological culture dating to about 2400–2300 BC, which stands at the head of the Early

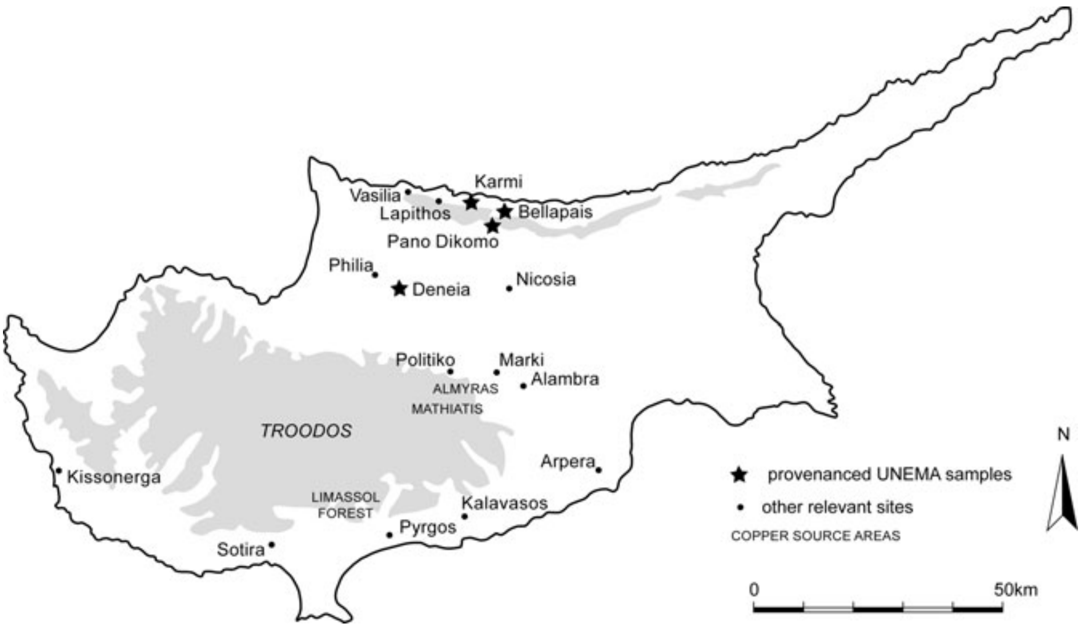

Figure 2
Map of Cyprus showing location of provenanced samples and other relevant sites (drawn by D. Frankel).

Bronze Age sequence on the island (Webb and Frankel 1999). The remaining four of the 13 metal items were acquired by the Cyprus Museum (CM 1959/IV–20/1–4). They include a chisel, a second axe with pierced butt, a second spearhead (with bent blade) and a second armband or ring-ingot (Fig. 3). Both axe (Fig. 4) and chisel are stamped with a linear sign. These objects were briefly published in Karageorghis (1960, 245, fig. 3) and Buchholz and Karageorghis (1973, 170, nos. 1867–70) (see also Tatton-Brown 1979, 27–8, nos. 49–50, where the text entry for no. 50 refers to the chisel (identified as an awl) but the illustration shows the perforated axe).

While the origin of the Colocassides items cannot be confirmed, their attribution to the Philia horizon is assured. The 11 ceramic vessels are of Philia Red Polished and Red Slip Wares (Webb 1997, 73–5, nos. 336–43). Heavy armbands or ring-ingots (see below), flat axes with polygonal butts and flat-tanged knives with wide midribs are distinctive types, either restricted to the Philia facies or readily distinguished from related EC and MC examples (Webb and Frankel 1999, 31–2; Swiny 2003, 370–2). Flat axes with perforated butts, although not otherwise attested in Philia metalwork, also certainly belong to this period as indicated by the recovery of a stone mould with a matrix of this type in a Philia context at Marki (Frankel and Webb 2001, 35–6, figs. 2.3, 10.2; 2006; Fasnacht and Künzler Wagner 2001, 40–1).

The two spearheads are more problematic. Both are of a distinctive tripartite type (described by Stewart as 'poker-butt'), with a leaf-shaped blade with high midrib, a circular-sectioned, horizontally-ridged butt and a long, heavy, square-sectioned tang tapering to a hooked terminal. They are unique in Cypriot metalwork but broadly paralleled by a number of examples from the second half of the third millennium from Silifke, Soli and elsewhere in Cilicia and Til Barsib, Kara Hasan and elsewhere in north Syria (Stronach 1957, 113–15, Type 5a, figs. 8.5, 9.3,

Figure 3
Artefacts possibly from Vasilia purchased by the Cyprus Museum from Petros Colocassides in 1959 (photograph Cyprus Museum).

pl. VIIb.3; Philip 1989, 70–1, Type 2, fig. 10). Stewart believed them to be Cypriot copies of a western Asiatic type (Stewart 1962, 245, 276, 350, Type AVIa). As the UNEMA example is a tin bronze and apparently of Anatolian copper (see below), they are better identified as imports, most probably from Cilicia. This receives further support from the fact that their relatively complex profiles suggest use of two-piece moulds, which are otherwise unattested in Cyprus at this date. These may, then, be the first objects of direct Anatolian origin to be identified in Cyprus in the Philia period, although gold (or electrum) spiral earrings from Sotira *Kaminoudhia* Tomb 6 (Swiny 2003, 376–9) and reportedly from Vasilia *Kafkallia* Tomb 1 (Hennessy *et al*. 1988, 26) are closely paralleled in EB II Tarsus (Goldman 1956, fig. 434.2) and perhaps also reached the island from Cilicia. Sherds of Cypriot Red-on-White and Black Slip and Combed Wares and a possible jug of Red Polished Philia Ware from EB II Tarsus, however, attest to some movement of goods in the opposite direction (Goldman 1956, 112–13, 128, 130, fig. 263.371–8; Peltenburg 1991, 31, 33, n. 5; Mellink 1991, 170–2, figs. 2–7; Swiny 1997, 172–3). Three gypsum vessels from Vasilia *Kilistra* Tomb 103 may also be imports (Merrillees 2003).

The badly damaged and bent rat-tang sword no. 8 is broadly at home in both western and central Anatolia and the Cypriot Philia repertoire (cf. Stronach 1957, 104–7, Type 1; Swiny 1986, 37–8, fig. 3; Philip 1991, 69–71, 73–4). Like the spearhead, however, it is of tin bronze and contains copper derived from an Anatolian, probably central Taurus, source (Bolkardağ). It is thus possible, indeed probable, that it reached Cyprus as a finished artefact. All other analysed hook-tang weapons from Early Bronze Age Cyprus, including two of Philia date, are of unalloyed or arsenical copper (Balthazar 1990, 308–9, Tables 71–2).

Figure 4
Axe or ingot possibly from Vasilia with a stamped linear sign (photograph Cyprus Museum).

The metal items offered for sale by Colocassides in 1959 may be compared with a deposit of nine metal artefacts found by Stewart in 1955 under the plaster lining of the dromos of Tomb 1 at Vasilia *Kafkallia* (Fig. 5) (Hennessy *et al*. 1988, 25–6, fig. 61; Frankel 1983, 126–7, nos. 1394–1400, pl. 52C; Stewart 1962, figs. 97.1, 98.5, 101.1–3, 102.20–1). It was largely this find, together with the similarity of artefact types and the quantity of metal found at Vasilia in general (Karageorghis 1966, 326–8, figs. 70–3; Hennessy *et al*. 1988, 38, fig. 53), which led to Stewart's identification of this site as the origin of the Colocassides material. So convinced was he of this provenance and of the integrity of the group that he identified it as 'Vasilia deposit 2', an attribution which entered much of the subsequent literature (Buchholz and Karageorghis 1973, 170; Balthazar 1990, 69, Table 59; Swiny 2003, 370–1, n. 6, fig. 8.2).

COMPOSITIONAL ANALYSIS

Compositional analysis was performed by Robert Glaisher (La Trobe University) using Energy Dispersive X-Ray Spectroscopy (EDS) with a JEOL JSM 840A scanning electron microscope (SEM) operated at 20kV. The x-ray spectrometer was a Link AN10000 system equipped with a SiLi detector with a resolution of 145eV and operated in beryllium window mode. Beam current was monitored with a Faraday cup detector and held at a constant value of 0.30 ± 0.1nA.

The samples, along with standards used for quantitative determination of sample chemistry, were collectively mounted onto a specimen holder using double-sided carbon tape.

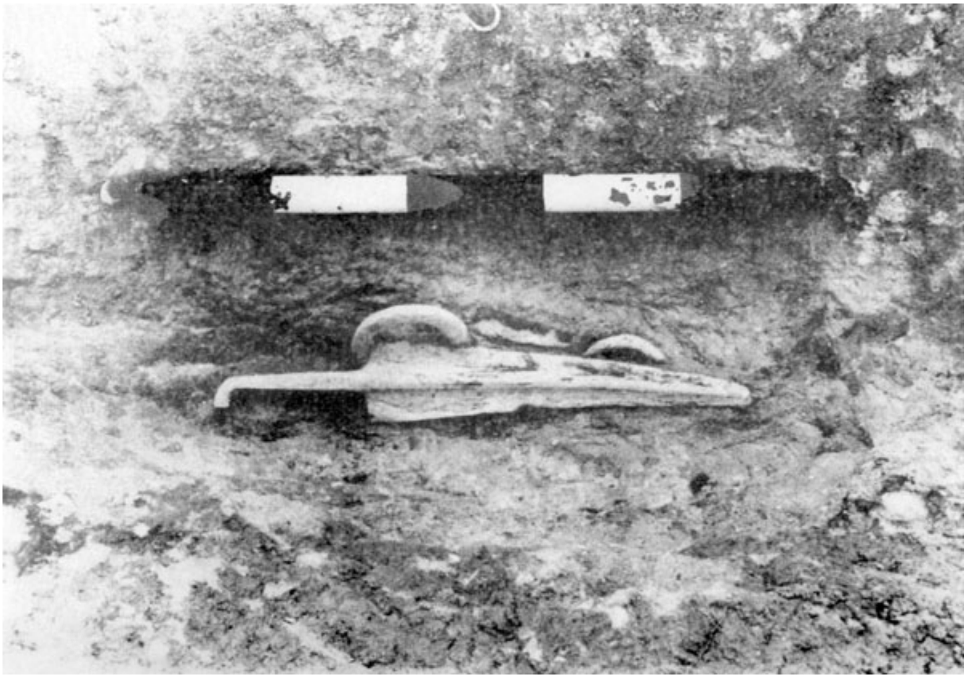

Figure 5
Collection of metal items uncovered by J.R. Stewart in the dromos of Vasilia Tomb 1 (photograph Mrs D.E. Stewart and J.B. Hennessy).

Internal standards used were lead metal (99.99 per cent purity), tin metal (99.999 per cent), iron metal (99.99 per cent), zinc sulphide (analytical reagent purity and pressed into a pellet using a pressure of 5 tons for 3 minutes) for a sulphur standard and semiconductor grade indium arsenide as an arsenic standard. The results are presented in Table 2.

LEAD ISOTOPE (LI) ANALYSIS (ZAS, NG)

The new lead isotope analyses of the UNEMA artefacts were carried out by Jon Woodhead and Roland Maas (University of Melbourne). Pb was separated using Sr Spec ion specific resin (Gale 1996), operated in nitric and hydrochloric acid media. A total procedural blank of 80 pg was measured which was insignificant for all analyses. Samples were run on a Nu Plasma MC-ICPMS mass spectrometer and corrected for instrumental mass bias using a Tl internal standard as described by Woodhead (2002). The results appear in Table 3. SRM 981 Pb isotope standards run concurrently provided the values in Table 4. These are within error of the double spike-corrected numbers quoted by Woodhead *et al*. (1995) and Todt *et al*. (1996). The analysis of sample no. 17 proved problematic and is not included.

Evaluation of the lead isotope analyses

The lead isotope (LI) analyses of the artefacts were compared with the database of LI data for ores and other Bronze Age Cypriot metals assembled in the Isotrace Laboratory in

TABLE 2
Compositional analysis using Energy Dispersive X-Ray Spectroscopy (in weight per cent; trace elements present at <0.1 per cent not recorded)

Sample	Artefact	Cu	Fe	S	As	Sn	Pb	Total
1	axe	98.21		0.16				98.37
2	axe	87.07				12.24		98.11
3	ring-ingot	95.72					1.47	97.19
4	spearhead	85.77		0.65		12.52		98.35
5	perforated axe	95.31		0.54				95.85
6	perforated axe	94.53	1.19	0.2	3.16			99.09
7	axe	96.94	0.65	0.71				98.3
8	sword	88.46				9.87		98.32
9	knife	97.19		0.76				97.95
10	knife	86.22	1.09	0.3	2.56			90.18
11	knife	94.07	0.68		2.7			97.45
12	knife	93.55	1.94	0.38	4.78			100.66
13	knife	92.04	0.6	0.18	3.29			96.11
14	knife	97.35	0.13	0.59	0.94			99.01
15	razor	92.87	1.68	1.17	2.73			98.45
16	razor	95.15			4.86			100.01
17	pin	97.53		0.54				98.07

TABLE 3
Lead isotope ratios for the UNEMA artefacts

Sample		206/204	207/204	208/204	208/206	207/206
1	axe	18.716	15.589	38.713	2.06836	0.83288
2	axe	18.756	15.643	38.837	2.07070	0.83407
3	ring-ingot	18.886	15.678	39.074	2.06893	0.83014
4	spearhead	18.949	15.696	39.096	2.06313	0.82830
5	perforated axe	18.915	15.717	39.114	2.06796	0.83097
6	perforated axe	18.706	15.628	38.774	2.07284	0.83545
7	axe	18.705	15.627	38.793	2.07287	0.83544
8	sword	18.974	15.678	39.000	2.05537	0.82626
9	knife	18.865	15.651	38.932	2.06358	0.82959
10	knife	18.709	15.631	38.785	2.07302	0.83545
11	knife	18.709	15.631	38.785	2.07301	0.83549
12	knife	18.769	15.676	38.897	2.07243	0.83524
13	knife	18.707	15.630	38.779	2.07294	0.83550
14	knife	18.773	15.668	38.887	2.07145	0.83457
15	razor	18.705	15.629	38.779	2.07317	0.83555
16	razor	18.707	15.631	38.785	2.07331	0.83559

TABLE 4
Values for SRM 981 Pb isotope standards run concurrently with the UNEMA samples

981-2	16.935	15.489	36.700	2.16711	0.91460
981-3	16.936	15.489	36.700	2.16702	0.91458
981-4	16.934	15.488	36.698	2.16710	0.91460
981-5	16.937	15.491	36.704	2.16704	0.91458

Oxford (UK) using Thermal Ionisation Mass Spectrometry (TIMS). This database is supplemented for ores from Turkey by analyses made by TIMS in Mainz, NIST and Tokyo (the primary references to these data are quoted by Sayre *et al*. 2001). Although the Nu Plasma MC-ICPMS was used here to measure the lead isotope compositions for the UNEMA samples, the two methods should yield fully comparable results, as indicated by the data for the SRM 981 standard quoted in Table 4.

LI provenance studies rely chiefly on comparisons between specific data points (lead isotope ratios of minerals from specific locations and metals, for example) and therefore the possibility of realistic interpretation of the analytical results depends on the availability of a sufficient database for comparison.

The database of lead isotope and elemental analyses of Bronze Age metals and ores used in this paper (OXALID) was assembled in Oxford between 1978 and 2001. During this time more than 2,000 lead isotope analyses were obtained on ore and slag samples collected during numerous archaeometallurgical and geological surveys in Greece, Cyprus, Italy, Spain, Israel, Egypt and Bulgaria. Together with relevant LI data published by other researchers, it includes over 2600 entries that can be used for comparisons with Mediterranean Bronze Age metals. This quantity of data seems substantial but there are still important gaps, including some Egyptian and Middle Eastern ore sources (for a full bibliography of LI data related to provenance studies see Gale and Stos-Gale 2000).

Three simple steps of comparison with the ore database have been used for the interpretation of results of lead isotope analyses of Bronze Age eastern Mediterranean metal artefacts:

1. Euclidean distances were calculated between the LI ratios of each artefact and all relevant and currently available lead isotope data points for ore and slag samples. The comparisons are made using simple software (TestEuclid) that calculates the Euclidean distance (TED) between the points in three-dimensional space defined by the three independent lead isotope ratios. The overall accuracy of the TIMS lead isotope analyses is ±0.1 per cent for each of the three LI ratios. The TED is expressed as the fraction of this error. That means that two points at *TED = 1* are identical within one analytical error and therefore the metal and the ore/slag can have the same geological origin.
2. In certain cases this approach shows that many ore samples from two or three geographically different regions have all three lead isotope ratios identical with an artefact, within the limits of the analytical error. Therefore the second stage of interpretation of the data must include the comparison of data on two-dimensional plots of LI ratios, to assess the patterns of distribution of all ore data points for each of the deposits in relation to the data points representing the artefacts.
3. Finally, the geochemistry and history of exploitation of the ore deposits identified as possible sources have to be evaluated.

In the great majority of cases (about 80 per cent) at the end of these procedures all but one ore source can be eliminated. Finally, the possibility of metal originating from a mixture of ores (or metals) from more than one source is evaluated. In the case of Late Bronze Age copper-based artefacts it is possible that some were made of remelted metal, but the pattern of all LI data indicates that this practice will for the most part have had little effect on the conclusions, because the number of copper sources used in the Bronze Age was limited and each region relied largely on local sources (Stos-Gale 2000). However, the Occam's razor principle is

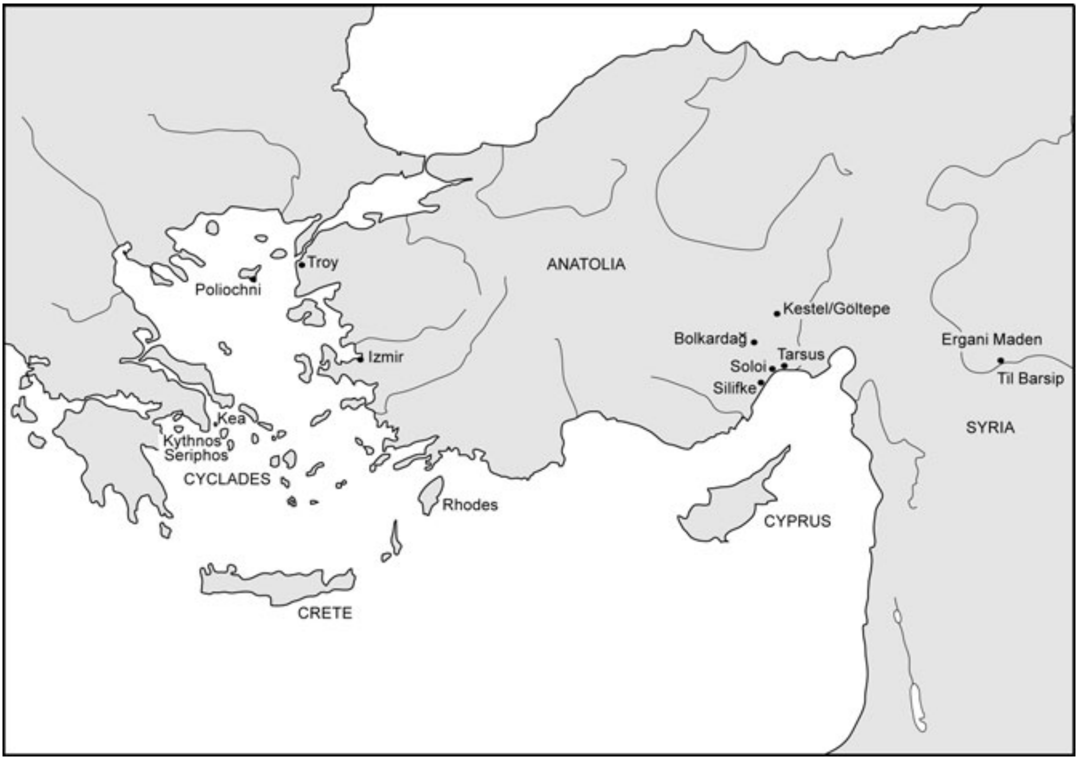

Figure 6
Map of the eastern Mediterranean showing the location of relevant sites and regions (drawn by D. Frankel).

applied whenever there is strong evidence for a single ore source. On the other hand this interpretation can be reconsidered if new data for ores or slags become available.

The identification of copper ore deposits exploited in the Bronze Age Mediterranean has been a central topic of research by archaeologists and archaeometallurgists for more than 30 years. Surveys of copper deposits in Greece, Italy, Turkey, Serbia, Bulgaria, Egypt, Oman, Iran, Jordan and Israel, as well as in the eastern Mediterranean, have provided much new information on this topic. There can be no doubt that Cypriot copper ores were exploited early, but intensive production of copper in the shape of oxhide ingots started only during the fourteenth century BC.

A number of very rich copper deposits in modern Turkey were exploited in the Bronze Age (Fig. 6). The one most often mentioned in the archaeological literature is Ergani Maden, near Elaziğ. Metal from this mine is in evidence amongst local prehistoric finds (unpublished analyses undertaken by A. Çukur and Ş. Kunç in the Isotrace Laboratory, Oxford). Specialized tin production complexes are also evident throughout the third millennium at Göltepe and the Kestel mine in the south-central Taurus Mountains in southern Turkey (Yener *et al*. 1989a; 1989b; 1991; Yener 2000. For a recent summary of the issues surrounding the mining and processing of tin at this site see Weeks 2003, 167–9). The coast south of the Taurus Mountains is known for its ancient ports, notably at Mersin.

In Greece copper deposits are much smaller than in Anatolia but copper was extracted during the Early Bronze Age on Kythnos, Seriphos and possibly Kea in the Cyclades and throughout the Bronze Age appears to have been exploited alongside silver and lead in the mines of Lavrion in Attica (Stos-Gale *et al*. 1988; Gale and Stos-Gale 1989; Stos-Gale 1998; 2001).

Interpretation of the lead isotope analyses

Figure 7 plots the lead isotope data for the UNEMA copper-based alloy artefacts in relation to that for some relevant copper ore deposits, whilst Table 5 summarizes the interpretation of the LI data for each of the analysed artefacts. Two of the Philia culture objects (nos. 4 and 8) are consistent with an origin from copper ores located at Bolkardağ in the central Taurus Mountains and a third (no. 9) with an origin at Ergani Maden in central south-eastern Anatolia. Ergani Maden could also be the origin of copper for the spearhead no. 4, which has a lead isotope composition bordering on that for both Bolkardağ and Ergani Maden. The spearhead (no. 4) and rat-tang sword (no. 8) also show a high tin content, an observation of particular interest given the contemporary exploitation of tin at Kestel in the south-central Taurus (Yener *et al*. 1989a; 1989b; 1991; Yener 2000).

Another two Philia culture objects, the armband or ring-ingot (no. 3) and perforated axe (no. 5), are marginally consistent with an origin from copper/iron ores occurring at Milyes on Kythnos in the Cyclades (see Gale and Stos-Gale 1989, fig. 2). The former (no. 3) contains 1.47 per cent of lead, which is not unusual as an impurity in Cycladic copper. In amplification, Figure 7 shows the relationship between the LIA for objects 3 and 5 and the data for the ores from the Milyes mine. The TestEuclid software shows that they lie slightly more than one standard error away from the Milyes ores, so that they are marginally consistent with having come from copper from the Milyes mine, whilst they are not consistent with any other ores or slags on our database. The Milyes mine was described by Davies (1935, 258–9). Although the direct evidence so far is for Roman mining, the mine has not been thoroughly explored and Bronze Age exploitation cannot be excluded.

A further two knives, one from Karmi *Palealona* (no. 12) and a Philia culture example (no. 14), have lead isotope compositions consistent with their copper coming from either Seriphos or Kythnos in the Cyclades. The lead isotope ratios of seven of the remaining artefacts (nos. 6, 7, 10, 11, 13, 15, 16) are essentially identical within ±0.1 per cent, and are compatible with the source of their copper being in Cyprus at either Mathiati, or Laxia tou Mavrou in the Limassol Forest region. The remaining two Philia culture objects, two flat axes (nos. 1, 2), are isotopically consistent with a source of copper from Petromoutti/Yerasa (see Stos-Gale *et al*. 1998, 252–5).

Comparison of these new lead isotope data with data for other artefacts from Bellapais *Vounous* and Vasilia previously analysed at Oxford, published by Stos-Gale and Gale (1994), shows that some originate from the same ores. Notably, the UNEMA Philia culture knife no. 9 has a lead isotope composition identical within error to an armband or ring-ingot from Vasilia (Stos-Gale and Gale 1994, 212, Table 11, 1957.24). Although the latter was previously attributed to an ore body at Malatya (Stos-Gale and Gale 1994, 212), the very substantial increase in the LI database of ores from Cyprus and Turkey since 1994, coupled with improvements in the methodology of interpretation, now suggests an origin for both at Ergani Maden. The Oxford data for a rat-tang sword from Vasilia (1957.22), which was tentatively attributed to an ore source

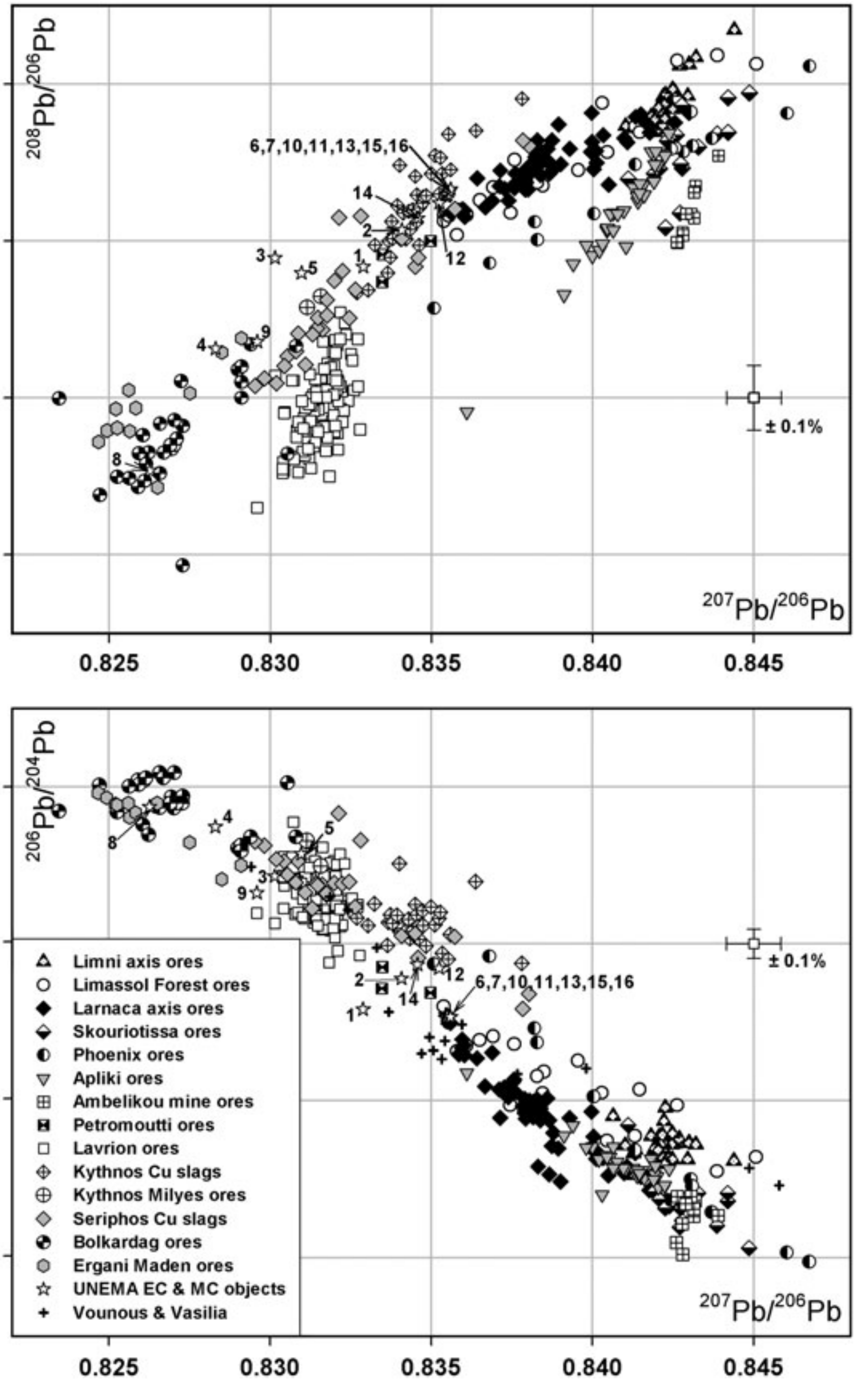

Figure 7
Lead isotope values for the UNEMA samples plotted against those from other relevant ore deposits (prepared by Z.A. Stos and N. Gale).

TABLE 5
Summary results of lead isotope analysis and its interpretation

Sample	Artefact	Pb208/Pb206	Pb207/Pb206	Pb206/Pb204	Origin of the copper	Date
1	axe	2.06836	0.83288	18.716	Cyprus: Limassol (Petromoutti)	Philia EC
2	axe	2.07070	0.83407	18.756	Cyprus: Limassol (Petromoutti)	Philia EC
3	ring-ingot	2.06893	0.83014	18.886	Cyclades: Kythnos (Milyes ores)	Philia EC
4	spearhead	2.06313	0.82830	18.949	Anatolia: Bolkardağ or Ergani Maden	Philia EC
5	perforated axe	2.06796	0.83097	18.915	Cyclades: Kythnos (Milyes ores)	Philia EC
6	perforated axe	2.07284	0.83545	18.706	Cyprus: Mathiati or Laxia tou Mavrou	EC III/MC I–II
7	axe	2.07287	0.83544	18.705	Cyprus: Mathiati or Laxia tou Mavrou	EC I
8	sword	2.05537	0.82626	18.974	Southern Anatolia: Taurus, Bolkardağ	Philia EC
9	knife	2.06358	0.82959	18.865	Anatolia: Ergani Maden	Philia EC
10	knife	2.07302	0.83545	18.709	Cyprus: Mathiati or Laxia tou Mavrou	EC III
11	knife	2.07301	0.83549	18.709	Cyprus: Mathiati or Laxia tou Mavrou	EC III/MC I–II
12	knife	2.07243	0.83524	18.769	Cyclades: Kythnos or Seriphos	EC III/MC I
13	knife	2.07294	0.83550	18.707	Cyprus: Mathiati or Laxia tou Mavrou	EC III/MC I
14	knife	2.07145	0.83457	18.773	Cyclades: Kythnos or Seriphos	Philia EC
15	razor	2.07317	0.83555	18.705	Cyprus: Mathiati or Laxia tou Mavrou	EC I
16	razor	2.07331	0.83559	18.707	Cyprus: Mathiati or Laxia tou Mavrou	EC III

in north-western Anatolia in Stos-Gale and Gale (1994, 212), are now seen instead to overlap more recently acquired lead isotope data for copper slags from the Cycladic island of Seriphos. This sword, together with UNEMA artefacts nos. 3, 5, 12 and 14, should all now be viewed as derived from Cycladic copper ores. Finally, the UNEMA axes (nos. 6–7), knives (nos. 10, 11, 13) and razors (nos. 15–16) from Deneia?, Bellapais *Vounous* and Karmi have lead isotope ratios identical within error which indicate that all are derived from Cypriot ores, from the mines of Mathiati or Laxia tou Mavrou. Similarly, the previous Oxford data for two daggers from Bellapais *Vounous* (Stos-Gale and Gale 1994, 212, Table 11, 45.23 and 111.52) are consistent with the copper for these daggers being derived from the same Cypriot copper deposits.

Lead isotope compositions do not necessarily relate to the place of manufacture of the artefacts but chiefly reflect the source of copper. It is possible that imported objects were reworked in local styles or that some copper was shipped around in the form of raw copper ingots. In Crete, for example, where all copper metal was imported from several sources (the Aegean including Lavrion, Cyprus, Anatolia and elsewhere), groups of stylistically similar Minoan metal artefacts consist of objects characterized by very different LI compositions which reflect these varied copper sources (Stos-Gale 2000; 2001).

DISCUSSION (JMW, DF)

Tin bronze

The identification of tin in three of the Colocassides objects (nos. 2, 4, 8) is of primary importance. For reasons already outlined, nos. 4 and 8 are likely to have been imported from Anatolia as finished artefacts. Both have LI ratios consistent with a copper source in the Bolkardağ region of the central Taurus Mountains. Axe no. 2, however, is of Cypriot type and shows a LI ratio consistent with copper ore from the southern Troodos region of Petromoutti near Limassol.

Tin bronze is otherwise attested in Philia metalwork only in the case of four small spiral earrings from Tomb 6 at Sotira *Kaminoudhia* (Giardino *et al*. 2003, 388–90). In this instance Swiny (2003, 379) suggests that tin bronze was used in order to achieve a colour effect similar to that of gold. Tin does not occur in Cyprus and is not present in Cypriot copper ores (Bear 1963; Muhly 1985). It must, therefore, have been imported either as a stanniferous mineral or in the form of ingots, scrap metal or bronze artefacts, the latter perhaps reworked over time to produce second or third generation bronzes in local styles (potentially causing compositional mixing). Tin is absent from all other Early Cypriot Bronze Age items analysed to date. Tin bronzes do not reappear in Cyprus until the early years of the Middle Bronze Age some time after 2000 BC (Balthazar 1990, 72–4, 161, 430–2; Stos-Gale and Gale 1994, 97–8; Gale, Stos-Gale and Fasnacht 1996, 373).

Copper

Nos. 1, 5, 7, 9, 14 and 17 are of relatively pure copper in which other metals are present as traces only. They are likely to have been cast from smelted copper ore rather than native copper, which exists in Cyprus but is rare and extremely pure (Gale 1991, 50; Giardino *et al*. 2003, 387). Ring-ingot no. 3 shows a significant presence of lead, in keeping with the suggested origin of its copper in the Cyclades (see above).

Arsenical copper

The remaining artefacts (nos. 6, 10–13, 15–16) are arsenical coppers. The minimum presence of arsenic required to distinguish the deliberate addition of this mineral from the use of ores naturally rich in arsenic is a matter of controversy. Branigan (1974, 71–3) suggested the presence of 1–2 per cent of arsenic as indicative of an intentional alloy while Craddock (1986, 153–4) argued for a deliberate alloying level of about 1 per cent arsenic. More recently Giardino *et al*. (2003, 388) have proposed a higher level of 2.5 per cent as the minimum threshold for deliberate Cypriot alloys, in which case seven of the UNEMA artefacts would be identified as deliberate alloys. Gale, Stos-Gale and others, however, argue on the basis of the analysis of copper prills in Bronze Age copper smelting slags that arsenical coppers were the result of the use in the furnace charge of copper ore with naturally occurring arsenic, rather than truly deliberate alloys (Gale, Stos-Gale and Gilmore 1985; Gale and Stos-Gale 1989. Zwicker (1986, 332–3) described azurite/malachite oxide-ores from Lavrion as naturally containing high quantities of arsenic which, on smelting, produced metallic copper containing more than 2.5 per cent arsenic. See also Rapp 2003, 464–5). High-arsenic ores exist in Cyprus, notably in the Limassol Forest area at Pevkos and Laxia tou Mavrou (Zwicker 1986).

Arsenical alloys have several technical advantages which are likely to have led either to the deliberate selection of arsenic-rich ores or to the selection of accidentally produced arsenical alloys: the presence of arsenic lowers the melting point of copper, acts as a deoxidant, improves castability, increases the strength of copper and makes it less brittle (Zwicker 1991). High-arsenic alloys are favoured for cutting, carving and sewing tools. The UNEMA examples are axes, knives and scrapers and date to EC III or MC I, with the exception of no. 15 which belongs to EC I. None of the Philia artefacts are of arsenical copper though arsenical coppers are otherwise represented in Philia metalwork from Sotira *Kaminoudhia*, Vasilia *Kafkallia* and Nicosia *Ayia Paraskevi* (Giardino *et al*. 2003, 387–8, M10, 12, 16, 20, 25; Balthazar 1990, 46, 54–5, 102–3, Tables 24, 38–9; *contra* Kuruçayirli and Özbal 2005, 178).

Copper ingots

The artefacts acquired by Stewart from Colocassides may include a number of copper ingots. The most likely candidate is no. 3, a solid, roughly-cast 'rope' of relatively pure copper bent into a ring with the ends joined. It is one of five objects of similar size, shape and weight in the Philia corpus. These include the second example acquired from Colocassides by the Cyprus Museum (Karageorghis 1960, 245, fig. 3) and three from the dromos deposit in Vasilia *Kafkallia* Tomb 1 (Stewart 1962, 251, fig. 101.1–3; Hennessy *et al*. 1988, 26, nos. 8–9, 15; Frankel 1983, 126–7, nos. 1396–7, pl. 52C). Two of the Vasilia rings are of unalloyed copper (Hennessy *et al*. 1988, 42; Balthazar 1990, 46, 55, 102, Tables 24, 39). The third has not been analysed (its identification as bronze in Hennessy *et al*. 1988, 26, no. 15 is not to be trusted).

These objects have been identified as armbands, armlets or bracelets (Hennessy *et al*. 1988, 26; Balthazar 1990, 420; Frankel 1983, 126–7; Stos-Gale and Gale 1994, 212, Table 11). With minimum diameters of about 6 cm, however, it is unlikely that they could have been worn by anyone other than a child and this seems unlikely given their weight which, in the case of no. 3, is 444 g. Alternatively, they may be identified as ingots or, more broadly, as media of exchange, as suggested almost 50 years ago by Stewart (1962, 288–9). Their size, weight and shape are well suited to distribution and their flat or bevelled surfaces would have allowed them to fit neatly alongside each other during transportation (Hennessy *et al*. 1988, 41, n. 5).

We have elsewhere suggested that perforated axes were also circulated as blanks or ingots (Frankel and Webb 2001, 35). Fasnacht and Künzler Wagner (2001, 41) have proposed that the piercing of the butt allowed a number of casts to be strung together for transport. While some objects of this type may have reached Cyprus from the Cyclades (see the LI results for no. 5), the discovery of a mould for casting perforated axes at Marki (see above) leaves no doubt that they were also produced in Cyprus in the Philia period. Three heavy flat axes with pierced butts from a late EC III or MC I tomb at Lapithos (Catling 1964, 63–4, Type B.I.D, fig. 4.5) were either manufactured earlier or indicate continued production during the EC period. The second perforated axe in the UNEMA, no. 6, is of similar type and reportedly from Deneia, a site occupied throughout the Bronze Age (Webb and Frankel 2001, 1–4). It weighs almost 1 kg and is of Cypriot copper. Axes with pierced or semi-pierced butts have also been recovered from MC tombs at Kalavasos (Wheeler 1986, 161, fig. 40.10, pl. XXXIII.3), Pyrgos (Belgiorno 1997, 121, fig. 12.6), Politiko and Arpera (Balthazar 1990, 240–1, 243, fig. 63).

The form in which copper was transported in prehistoric Bronze Age Cyprus has long been a matter of debate (see Swiny 1989, 28). It may now be suggested that ring- and axe-shaped ingots were used, although at present only the latter can be demonstrated to have been produced in Cyprus. An arsenical copper knife- or dagger-shaped object of Philia date from Sotira *Kaminoudhia*, weighing 114 g, has also been identified as an ingot (Giardino *et al*. 2003, 391. See, however, Swiny 2003, 373). These types fall into three distinct weight categories: of around 100 g (dagger-shaped), 400 g (ring-shaped) and 1000 g (axe-shaped). Additional casting moulds from Marki indicate the production, also, of boat- and tongue-shaped ingots, with weights estimated at 220 g, 460 g and slightly over 500 g, at least as early as EC III (Frankel and Webb 2001, 35, fig. 10.2, 11; 2006; Fasnacht and Künzler Wagner 2001, 38–40). Two fragmentary moulds from Alambra, used to produce bar ingots, are of MC date (Gale, Stos-Gale and Fasnacht 1996, 135–6, A10–11, fig. 31).

Sources of copper

The LI analyses suggest that three of the Philia artefacts may be made of Anatolian (nos. 4, 8–9) and three of Cycladic copper (nos. 3, 5, 14). A foreign origin for nos. 4 and 8 is also indicated by their composition and typology. Both are of tin bronze and, as suggested above, are likely to have been imported as finished artefacts from Anatolia. Nos. 3 and 5, identified here as ingots, appear to be of copper from the Cyclades. Ring-ingots are not currently attested there, although perforated flat axes of somewhat different type are known from the Cyclades and south-east Aegean (Branigan 1974, 166, pl. 13, 29, nos. 610–12, 615–16, 625, 628). The two remaining objects apparently of non-Cypriot copper, knives nos. 9 and 14, are typologically at home in both the Cypriot Philia repertoire and in central and western Anatolia and could have been cast in either area (Stronach 1957, 92–6, Type 2c; Swiny 1986, 37–8; Swiny 2003, 372; Philip 1991, 73–4). Conversely, axe no. 2 is of Cypriot copper alloyed with imported tin, indicating the occasional production of bronzes using imported tin and local copper during the Philia period. The tin bronze earrings from Sotira also appear to have been made on the island and may represent a similar phenomenon or perhaps the reworking of imported bronze (Giardino *et al*. 2003, 389).

In combination, then, LI analysis and other lines of evidence suggest that copper and tin, in both ingot form and as finished copper and bronze artefacts, were reaching Cyprus in the early years of the second half of the third millennium from a variety of sources. Earlier LI analyses have also identified non-Cypriot ore in a fragmentary copper axe from Philia Period 5 at Kissonerga in the south-west (Gale 1991, 53–4, fig. 9; Peltenburg 1998, 189, pl. 36.1) and Anatolian and Cycladic sources are now also argued, respectively, for a ring-ingot and rat-tang spearhead from the dromos deposit in Vasilia *Kafkallia* Tomb 1 (see above).

The distribution of metal

LI data suggest that virtually identical ring-ingots found in Cyprus are from different sources and potentially of Cycladic (Kythnos) and central south-eastern Anatolian (Ergani Maden) origin. Similarly, axe-ingot no. 5 is identified as Cycladic copper, while the Marki mould shows that such ingots were also produced in Cyprus, presumably using Cypriot copper. In addition to those noted above from the Aegean, perforated flat axes have been found at Soli-Pompeiopolis, indicating their distribution also in coastal Cilicia (Bittel 1940, 194–7, pl. V, nos. S3446, S3448, S3465).

If the LI attributions are accepted, it would appear that copper from the Cyclades and central south-eastern Anatolia was circulating in the eastern Mediterranean in the form of ring-ingots and that metal from Cyprus, the Cyclades and possibly also Anatolia was cast in the form of perforated axe-shaped ingots. This use of identical ingot types across the Aegean and western Asia suggests that common forms of metal 'currency' were in use in the mid-third millennium and that ingots from different ore sources were moving in similar forms across large distances. Cyprus appears to have been both receiving raw material from foreign sources and adopting 'international' ingot forms from the earliest phase of local production. The possible presence of Cypriot copper in Early Minoan Crete suggests, further, that the island was also exporting copper at this time (Stos-Gale and Macdonald 1991, 267). This evidence for trade between Cyprus and the west is surprising, given the absence of other material indicators of contact between Cyprus and either Crete or the Cyclades at this time. Interaction may, however, have been both indirect and limited to the exchange of raw materials. Cypriot ore has also been identified recently in an EB axe from Pella in Jordan, although the suggested date for this object of *c*.3000 BC seems remarkably early (Philip *et al*. 2003, 86–7; Stos 2003, 94, fig. 16).

Three general stages in the distribution of Cycladic metals in the Aegean have been suggested by Broodbank (2000, 292–3, 299–319, fig. 106). Limited interaction during the EB I–EB II transition was followed by an expansion early in EB II. Cycladic links to Crete subsequently declined in late EB II (after about 2400 BC), but at this time connections with the Near East appear to have intensified and an increasing westward flow of raw materials, finished products and presumably technologies can be identified (Broodbank 2000, 283–5). Both copper and tin (perhaps as tin bronze) were imported into the region from outside the Aegean (Stos-Gale *et al*. 1984; Gale, Papastamataki, Stos-Gale and Leonis 1985) with the appearance of the alloy perhaps of more immediate significance than its mechanical advantages (Broodbank 2000, 293). The identification of Cycladic copper in four EC Philia and one EC III/MC I sample may provide evidence of the reciprocal nature of this interaction, expanding the distribution of Aegean material beyond the current boundary at Rhodes (Broodbank 2000, 285).

Hoard(s) of metalwork at Vasilia

The 13 metal items offered for sale by Colocassides in 1959 may, as already noted, be compared with nine metal objects from Vasilia *Kafkallia* Tomb 1. The latter include three ring-ingots, a spearhead with bent blade, a knife, two toggle pins, a razor or knife fragment and a rivet (Hennessy *et al*. 1988, 26, fig. 60). These have been identified as grave goods (Hennessy *et al*. 1988, 26; Manning 1993, 45; Keswani 2004, 38, 63, 83). They were, however, found beneath the plaster floor of the dromos, in close proximity as though contained in a bag (Hennessy *et al*. 1988, 25, fig. 55a–b. Here Figure 5). This is atypical of the placement of grave goods in Bronze Age Cyprus, which were normally openly displayed in the chamber. It is proposed here that the *Kafkallia* deposit should instead be identified as a cache of items concealed during the construction, use or maintenance of the dromos. Its location suggests the possibility of retrieval and the intention is unlikely to have been to remove this material from circulation permanently.

The items offered for sale by Colocassides in 1959 are similar to those from Vasilia *Kafkallia* Tomb 1 and may have had a similar origin. Both groups are characterized by the presence of ingots, worn, damaged and bent objects of medium to large size and finished unused items, present, in the case of the Colocassides axes, in multiples. Both also lack spiral earrings, otherwise the most common metal items in Philia tombs (see Table 6), and small domestic objects such as awls and needles. Of considerable interest are the linear signs stamped on the axe and chisel

TABLE 6
Distribution of provenanced Philia metal artefacts by site

	spearhead	knife	axe	chisel	razor	ring-ingot	pin	needle	awl	earring	Total
Vasilia	2	2	2		1	3	5				15
Colocassides group (Vasilia?)	3	2	5	1		2					13
Nicosia *Ayia Paraskevi*	1	4	1							9	15
Philia *Laksia tou Kasinou*		4	1		1		3			3	12
Kyra		4								5	9
Marki		2		1	1?		1	9	1	3	18
Sotira *Kaminoudhia*		2 (1 = ingot?)							3	9	14
Kissonerga *Mosphilia* 5			1							1	2
Deneia		1								2	3
Total	6	21	10	2	3	5	9	9	4	32	101

acquired by the Cyprus Museum (Karageorghis 1960, 245, fig. 3). Isolated signs also appear, occasionally, on Philia pottery and on an unprovenanced Philia axe in the Cyprus Museum (Dikaios 1937–39, 201, pl. XLI.1; 1962, figs. 80.22, 82.25; Stewart 1999, 164, pl. XXV.3, 7) as well as on a knife from the Soli-Pompeiopolis hoard (Bittel 1940, 187, fig. 4, pl. III).

The presence of ingots and broken, damaged and unused objects, and the absence of personal and symbolic items identify these as utilitarian deposits and most probably as metalsmiths' or merchants' hoards (see Levy 1982, 21–2; Knapp *et al*. 1988, 236–8, Table 1; Bradley 1990, 11–14, Table I). Merchants' hoards are normally defined as consisting of complete objects, especially multiples of single types and newly-made items, while founders' or smiths' hoards comprise materials collected primarily for their value as metal, characterized in particular by broken objects or scrap metal, rough castings, slag and ingot fragments. The *Kafkallia* Tomb 1 deposit and the Colocassides group combine elements of both but lack direct evidence of metalworking in the form of slag, moulds, castings and ingot fragments. Perhaps raw materials, both in ingot form and as items ready for remelting, served as media of exchange and, along with finished objects, were part of the stock-in-trade of a merchant.

The identification of one and possibly two merchant's hoards at Vasilia suggests that this site was connected with the accumulation, distribution and recycling of metal. While we cannot guess at the circumstances behind their concealment and the subsequent failure to retrieve them, they suggest that at some time during the use of the cemeteries at Vasilia it became necessary for some individuals to hoard or cache metal wealth. They also suggest the presence at this site of traders or merchants, perhaps of non-Cypriot origin, whose stock-in-trade included copper from Anatolia, the Cyclades and Cyprus and objects of unalloyed and arsenical coppers and tin bronze.

The association of non-ritual hoarding, especially of metal, with times of crisis has been well documented (Knapp *et al*. 1988). Among the most notable instances are several hoards of bronze tools and weapons at Troy from the end of EB II, which are roughly contemporary with an array of EBA Aegean hoards, mostly comprised of woodworking or carpenters' tools (axes, chisels and awls) (Renfrew 1972, 325–8; Branigan 1974, 132–4, 142–4; Knapp *et al*. 1988, 234–5, fig. 1). These can generally be seen as representing accumulations of wealth buried in the face of impending danger. At Troy and Poliochni hoard burial was quickly followed by destruction at the end of EB II. The Vasilia hoards, if such they are, may be part of a similar local circumstance involving considerable socio-economic insecurity. If the deposits date to the latter part of the Philia period, as suggested by the tripartite spearheads (see below), their burial and the subsequent failure to retrieve them may be related to the abandonment of the site, which has no documented occupation from the following EC period.

The role and chronology of Vasilia

Vasilia commands an excellent harbour as well as a pass at the western end of the Kyrenia Mountain range to the Ovgos Valley and the ore bodies of the northern Troodos (Fig. 8). Stewart believed it to have been one of the main land terminals of a copper route and perhaps the main export centre of the copper trade (1957, 3; 1962, 288–9). This receives some support from the quantity of metal recovered and the extent of Philia phase occupation, recorded from some six locations in the immediate vicinity of the modern village (see Swiny 1997, 180–2). At present 15 per cent by number (and a very much greater percentage by weight) of all provenanced Philia metal comes from a handful of looted tombs at these locations (Table 6). If the Colocassides items are added to this tally, it rises to an impressive 28 per cent. While these raw numbers are

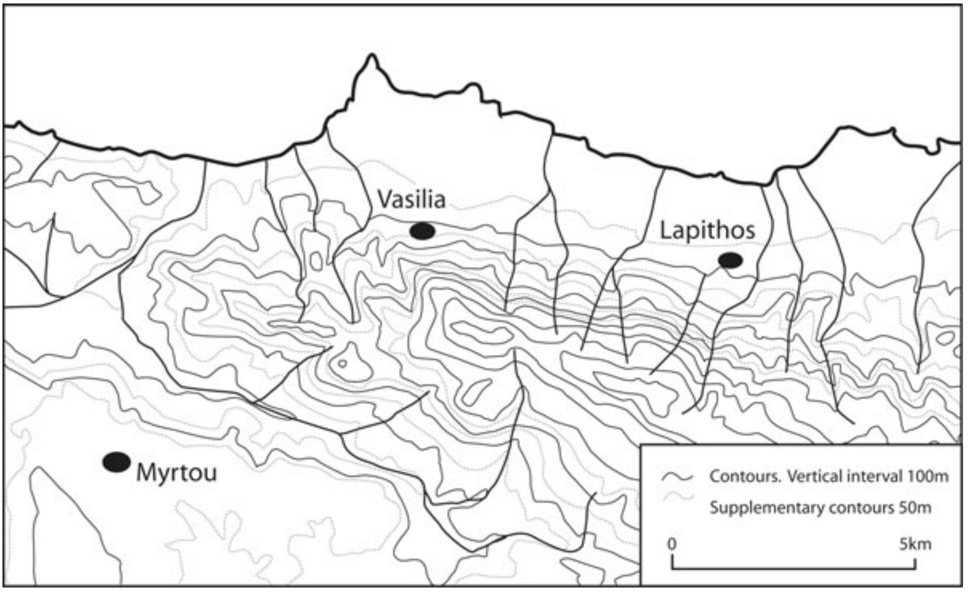

Figure 8
Topographical map showing the location of Vasilia (drawn by D. Frankel).

considerably skewed by differences in the extent of excavation and salvage and modes of deposition (hoards, burials and settlement refuse), the Vasilia region nevertheless stands out with regard to the quantity, size, weight and typological range of metal artefacts.

The chronological position of Vasilia within the Philia/EC sequence has long been a problem in Cypriot archaeology. The elaborate construction of the tombs, particularly at *Kafkallia*, is unparalleled at other Philia sites and includes some features not found again until the MC period. This, together with the attribution of some metal items to the late third millennium (see below), has led to major difficulties in the interpretation of the site. Stewart's own view was that the Philia phase lasted in some parts of the island, including Vasilia, until EC III (Stewart 1962, 270, 275; Hennessy *et al*. 1988, 41). Alternatively, Swiny has proposed either that wealthy Middle Bronze Age Cypriots imitated earlier ceramic and metallurgical traditions, producing a chronologically eclectic range of metal types in order to legitimize newly acquired territorial rights, or that the *Kafkallia* tombs were constructed in the MC period and used as repositories for earlier material accidentally discovered in the vicinity (Swiny 1997, 184–5).

Recent excavations at Marki, however, have shown that the Philia culture ante-dates the normative EC sequence and the proposal that Vasilia and other sites were contemporary with north coast EC I–III is no longer tenable (Webb and Frankel 1999, 37–8; Frankel and Webb 2006). Swiny's suggestions (1997, 184) also provide an unlikely explanation for perceived chronological anomalies in metal assemblages from or reportedly from *Kafkallia*. These anomalies may, indeed, be more apparent than real. Copper-base armbands, as Swiny notes, are otherwise unknown during the Cypriot Bronze Age. This is, at best, a negative argument as they are also unknown from earlier or later periods. If they are ingots, as argued here, their absence from grave assemblages is to be expected. Swiny's second argument relates to the recovery of pinched-spring tweezers in Tomb 2 at *Kafkallia* (Hennessy *et al*. 1988, 28, fig. 53). Tweezers do not otherwise pre-date EC III and their presence is cited in support of a late EC or early MC date for the cemetery (Stewart 1962, 270; Swiny 1997, 184; Philip 1991, 74). Tomb 2, however, had been thoroughly looted and was used as a coiner's workshop in the nineteenth century AD (Hennessy *et al*. 1988, 41, n. 7), providing a more than adequate explanation for the presence of tweezers and the only other object recovered – an 1890 half-piastre (Webb and Frankel 1999, 33). Swiny also notes the absence of spiral earrings. This is, however, in keeping with the identification of both the Tomb 1 dromos hoard and the Colocassides group as merchants' or metalworkers' caches.

The remainder of the metalwork recovered or probably recovered at *Kafkallia* and other cemeteries in the Vasilia area is consistent with a date in the early years of the second half of the third millennium, with the possible exception of the two tripartite spearheads. Stewart believed these to be of Western Asiatic MB I type (Stewart 1962, 276. Also Swiny 1997, 184). A parallel, however, is provided by an example from the Soli hoard, which was associated with perforated axes and flat-tanged knives of similar type to those in the Colocassides group. While allowing for the possibility of earlier examples, Stronach (1957, 115) suggested a chronological range of 2300 to 2100 BC for spearheads of this type. A date of *c*.2300 BC would place the two Cypriot examples toward the end of the Philia period (Bolger *et al*. 1998, 20–1; Manning and Swiny 1994) and provides a *terminus ante quem* for the deposition of the Colocassides material if it did indeed enter the archaeological record at a single point in time.

In short, there is no reason to doubt the chronological integrity of the material offered for sale by Colocassides in 1959 or the attribution of the metal finds from Vasilia *Kafkallia* to the Philia horizon and therefore to the period between about 2400 and 2300 BC. This is consistent with the ceramic data from *Kafkallia* which belongs wholly to the Philia facies. The 'important and perplexing dilemma' (Swiny 1997, 185) of Vasilia can now, then, be laid to rest and this locality allowed to take its rightful place as one of the most important areas of Philia settlement on the island. The size of the burial grounds, the remarkable construction and sophistication of the tombs at *Kafkallia* and the quantity, size and nature of associated metal goods proclaim the exceptional nature of this coastal locality, which was receiving raw materials and finished goods from various sources and may itself have been a participant in the long-distance trade networks stretching from the Aegean to Cilicia and perhaps as far as north Syria (see, most recently, Şahoğlu 2005).

The introduction of metallurgy to Cyprus

While small-scale processing of local copper is evident at Late Chalcolithic Kissonerga in the south-west of Cyprus (Peltenburg 1998, 188–9), a complex metal industry seems to have appeared quite suddenly in Cyprus around 2400 BC and to have developed rapidly in something akin to the so-called *Metallschock* visible in the Aegean in EB 2 (Renfrew 1972, 338; Nakou 1995, 1–2, fig. 1; cf. Broodbank 2000, 292–3). Compositional results reported here and elsewhere leave no doubt that metalsmiths in Cyprus at this time had the expertise required to produce arsenical coppers and access to imported tin and copper. If Vasilia and perhaps other ports on the north and west coasts were involved in an interregional metal trade, this may have provided the initiative and the expertise for an exploration of the island and the subsequent development of a local industry. Philia metal artefacts are closely related to western and central

Anatolian types, leaving little doubt that influences from one or both of these areas were dominant in the development of the Cypriot repertoire.

The introduction of a fully-fledged metallurgical industry is only one of an array of developments which mark off the Bronze Age from the Chalcolithic on the island. Most scholars accept an Anatolian source for many, if not all, of these innovations. The process, however, by which they reached Cyprus remains controversial. Debate has long polarized around opposing models of internal restructuring on the one hand (Stewart 1962, 270; Manning 1993; Knapp 2001) and population movement on the other (Dikaios 1962, 202–3; Gjerstad 1980, 11–13; Webb and Frankel 1999; Frankel 2000; Webb 2002). A somewhat more complex model has, however, been developed by Peltenburg (1991; 1998, 256–60, Table 14.7), whereby relatively casual contacts between Cyprus and the Anatolian mainland during the Late Chalcolithic were followed by more intensive interaction culminating in the arrival of settlers at the beginning of the Philia period. General parallels may be drawn between the histories of these developments in Cyprus and more-or-less contemporary events in the Aegean, although quite different processes may have been involved.

The evidence presented in this paper suggests that the north coast of Cyprus was part of, or at least active in, a broad-scale maritime interaction sphere principally concerned with the movement of raw metals and perhaps of associated technologies at least as early as 2400 BC. Increasing indications of an extensive trade network, linking south-eastern Anatolia via central and western Anatolia to the east Aegean, the Cyclades and mainland Greece, have been provided by recent excavations in the Izmir region and elsewhere in coastal west Anatolia (Kouka 2002, 296–302; Şahoğlu 2005). Direct or indirect participation in such a system (characterized as the Anatolian Trade Network) appears to have resulted in the arrival on Cyprus of imported ingots and finished artefacts and is likely to have involved some reciprocal outward movement of Cypriot copper. A general demand for metal may have prompted exploration of the interior and led to the establishment of copper ore extraction and production technologies on the island. Mellink's suggestion (1971, 173) that Anatolian metalsmiths sought new sources of copper in Cyprus as a potential supply for Cilicia receives some support from typological parallels evident between Philia and Cilician metalwork and the import, suggested above, of spearheads and perhaps other artefacts from this region. That this was ultimately a more broadly based migration, however, is indicated by the wider array of technologies and behaviours which characterize the Philia.

For some time, at least, Philia Cyprus must have remained in contact with the Anatolian mainland and a participant in the interregional metal trade. The lack of tin and the absence of imported copper in EC I to EC III metal artefacts (with the exception of no. 12) suggest, however, that this interaction was not maintained. Cyprus appears to have dropped out of the inter regional commodity network around 2300 BC. It is too early to say whether this was due to internal factors, competing demands within Anatolia or a more general disruption of trade networks. Tin bronze reappears in Cyprus around 2000 BC at much the same time as Assyrian trading colonies were established at Kültepe and elsewhere. These colonies changed the dynamics of tin production and distribution within Anatolia and established new regional interaction systems which may have been responsible for a renewed flow of tin to Cyprus (Yener 2000, 15, 75; Şahoğlu 2005, 355). A related, but perhaps independent, factor may have been the development of deep-hulled sailing ships, which transformed the nature of maritime interaction in the eastern Mediterranean and provided the means and social and economic incentives for new forms of exchange (Broodbank 2000, 341).

CONCLUSION

Compositional and lead isotope analyses, viewed in association with typological studies and the broader archaeological context, suggest that the development of metalworking in Cyprus took place within a more complex set of regional interactions than previously appreciated. We may now envisage an extensive network involving the sea-borne movement of metals and metal artefacts between the Aegean, coastal Anatolia and Cyprus in the early years of the second half of the third millennium. These areas appear to have been linked, however indirectly, to the same metal sources and to have been engaged in the production of similar if not identical media of exchange. This may be seen in the context of increasing evidence for long-range resource acquisition networks extending from the Aegean along the western and southern coasts of Anatolia and perhaps as far as the southern Levant from the early third millennium (Philip *et al*. 2003; Kassianidou and Knapp 2005, 236–8; Şahoğlu 2005).

The role of Cyprus in this interaction is still poorly understood. At present only the north coast port of Vasilia can be seen to have participated directly and, if the Colocassides metal is from this site, to have been receiving both imported raw materials and finished artefacts. Whether these items were brought to the island by Anatolian metalsmiths or migrants, acquired from the mainland by Cypriot elites or obtained via an entrepreneurial seaborne trade conducted by Cycladic or Anatolian voyagers, remains uncertain. It would appear, however, that some communities on the island were participating in or were, at the very least, recipients of a systematic long-distance exchange in metals during the Philia period.

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