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THE SOURCE PROVENANCE OF BRONZE AGE AND ROMAN POTTERY FROM CYPRUS*

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Archaeological interpretations of ancient economies have been strengthened by chemical analyses of ceramics, which provide the clearest evidence for economic activity, and comprise both the objects of exchange and its means. Pottery is often manufactured from local materials, but its compositional diversity typically prevents significant patterns of resource utilization from being identified. Centrally located and positioned on traditional shipping routes, Cyprus maintained ties with and supplied a variety of distinctive ceramic products to the major commercial centres in the eastern Mediterranean throughout Antiquity. We analysed two Cypriot fine wares and a variety of utilitarian pottery, as well as samples of extant Cypriot clays to determine source provenance. These chemical analyses provide an objective indication of the origins of ancient (Bronze Age and Roman) ceramics manufactured on Cyprus. The distribution of the probable clay sources and the links between pottery style and the material environment also afford a perspective on the spatial organization of large-scale pottery production on the island. Compositional analysis provides the means to assemble geographies of pottery production and to unravel the interregional system of exchange that operated in Antiquity, but the ability to accomplish these tasks is predicated on systematic analyses of ceramic products and raw materials that are found far beyond the bounds of individual archaeological sites.

KEYWORDS: CYPRUS, BRONZE AGE, ROMAN, NEUTRON ACTIVATION ANALYSIS, POTTERY PRODUCTION, WHITE SLIP, CYPRIOT RED SLIP, ARCHITECTURAL TERRACOTTAS

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INTRODUCTION

Attempts to specify the geographical source of the deposits that artisans in ancient societies drew on to manufacture lithic, ceramic or metal artefacts are predicated on links forged between the composition of a raw material and the finished products derived from it (Rapp 1985). As well as providing a palpable link to the raw materials used to manufacture artefacts found at archaeological sites (Bishop *et al*. 1982; Bishop and Neff 1989), source provenance studies can also furnish an appreciation of the spatial aspects of economic activity by helping to delineate patterns of production and exchange in ancient societies (Adan-Bayewitz 1993, 60–82; Knapp and Cherry 1994, 158–61). In the case of objects made from distinctive earth materials such as obsidian, which may be traced to specific outcrops, source provenance is determined on the basis of direct comparisons with extant raw materials (Williams-Thorpe 1995).

It has proved more difficult to connect pottery with extant raw materials, because there is a myriad of prospective clay sources in the vicinity of most archaeological sites, and the nature of the production process and post-depositional alteration cause compositional variations between the ceramic fabric and the raw material(s) from which it was fashioned (Brooks *et al*. 1975; Freestone *et al*. 1985; Kilikoglou *et al*. 1988; Arnold *et al*. 1991; Adan-Bayewitz 1993, 45–7). The links are all the more enigmatic because clays are commonly mixed during the production process and pastes are levigated and tempered. Some clay sources were also undoubtedly exhausted in Antiquity. Thus the source provenance of pottery is typically elucidated through comparisons with reference ceramics in control groups that are derived from sites where either the presence of a kiln or product abundance implies production (Wilson 1978; Rapp 1985; Bishop and Neff 1989; Knapp and Cherry 1994, 8–10). Mineralogical and petrographic analysis has long been employed in conjunction with stylistic criteria to elicit the provenance (Williams 1985). Chemical analysis provides an alternative means of characterizing pottery and of establishing source provenance in the form of a probable relation to known earth materials (Bishop *et al*. 1982; Harbottle 1982). Tentative attempts have been made to delineate production areas (Maguire 1987; Empereur and Picon 1989; Knapp and Cherry 1994, 158–61). Nevertheless, the geography of pottery production in the ancient world remains obscure, because attempts to relate pottery and clays often produce equivocal results (cf., Vaughan 1991; Adan-Bayewitz 1993, 60–82).

Cyprus occupied a pivotal position on trade routes between the Mediterranean and the Near East, and the island's archaeological record provides a unique perspective on the interface between internal production and external exchange in the ancient world. A number of previous studies have generated compositional data for Cypriot pottery and have connected pottery found elsewhere in the eastern Mediterranean to the island (Bieber 1977; Gunneweg *et al*. 1983; King *et al*. 1986; Knapp and Cherry 1994). These studies suggest that compositionally distinct pottery is present in the material record of different Cypriot sites but, despite the island's relatively small area, no consensus has emerged about the relation between the geographical distribution of any ceramic product and its place of origin (Bieber 1977, 131–44; Jones 1986, 574–89; Vaughan 1991; Knapp and Cherry 1994, 158–61; Bryan *et al*. 1997).

In this paper, we summarize the results of compositional analysis of 371 sherds obtained from 30 Bronze Age and Roman sites on Cyprus (Fig. 1, Table 1). The sherds are predominantly of six types and represent three ceramic categories. Fine-grained, slipped table pottery includes three wares that appear to be widely distributed in the eastern Mediterranean and for which a Cypriot provenance is commonly accepted: Late Bronze Age White Slip II (WS), Early Roman Cypriot Sigillata (CS) and Late Roman Cypriot Red Slip (CRS: Popham 1972; Hayes 1967,

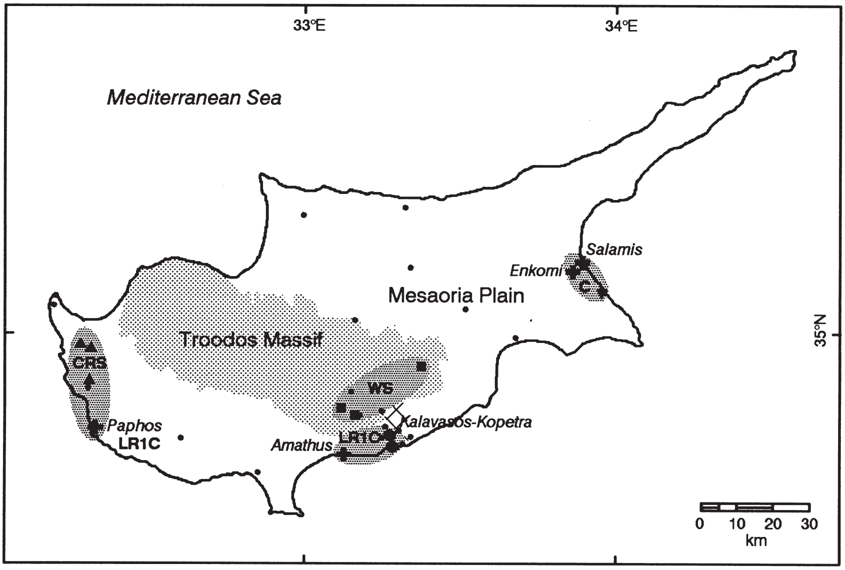

Figure 1 *Late Bronze Age and Roman towns on Cyprus and source provenance of White Slip II (WS) and Cypriot Red Slip (CRS) pottery, LR1C amphoras and Corinthian-style (C) roof tiles. Ellipses highlight the geographical location, not the spatial extent, of the source areas. Solid dots show the distribution of archaeological sites contributing ceramics listed in Table 1. Other solid symbols correspond with Figure 2 and mark locations of the extant clays (listed in Table 1) that evince source provenance. The location of the lower part of the Vasilikos Valley is shown by cross-hatching.*

1972; Jones 1986). Locally manufactured transport vessels are represented by Late Roman 1-style amphoras in a characteristically coarse-grained fabric that occurs across the island (LR1C: Williams 1987). Two sets of Late Roman roof tiles—one of standard Corinthian shape, the other of curved, almost Laconian, form—are known from many Cypriot sites but are unreported on the mainland (Rautman *et al*. 1993). As a group, these wares represent some of the most distinctive products of an insular manufacturing tradition that extends over a span of nearly two millennia, from the Late Bronze Age (*c*. 16th–12th centuries BCE) to the Late Roman period (*c*. fourth–seventh centuries CE).

Although previous studies have examined the origins of pottery exchanged between Cyprus and the mainland (e.g., Knapp and Cherry 1994, 123–55), utilitarian ceramics, which can help to delineate local economies by highlighting components of continuity and transformation within regional patterns of ceramic exchange (Adan-Bayewitz 1993, 19–22), are often ignored. We initially explored these interrelated issues by focusing on ceramics derived from sites in the environs of the Vasilikos Valley of south-central Cyprus (Rautman *et al*. 1993); a locale that supports numerous archaeological sites, including a large, prosperous Late Bronze Age site (*Kalavasos-Ayios Dhimitrios*) and a rural Late Roman community (*Kalavasos-Kopetra*) that, despite its small size and limited resources, was prosperous enough to have access to commodities from across the Mediterranean. This data set has now been expanded to include virtually the entire spectrum of raw materials available to Cypriot artisans in Antiquity. It incorporates 132 samples of extant clays derived from all the major commercial and numerous local deposits of stiff, tenacious earths identified from soil maps and field surveys that extended to most parts of Cyprus. A well-established technique, neutron activation analysis, was used to obtain

Table 1 *Sites and locations from which ceramic and clay samples collected as part of this study were obtained. Symbols (matching those in Figs 1 and 2) indicate the compositional group to which materials from a particular site or location belong (sites/locations associated with materials analysed by Bieber (1977) and Gunneweg et al. (1983) are not listed)*

Site/location	*WS*		*CRS*	*C*	*LR1C*
Ceramics					
Akamas			●		
Aredhiou–*Koladhes*	●				
Amathus			●		
Athienou–*Malloura*			●		
Ayios Kononas–*Kioni*		●			
Bellapais				●	
Cape Arnauti			●		
Dhiorios			●		
Episkopi–*Bamboula*	●				
Kalavasos–					
Alonia tou Pano Zyou	●				
Ayios Demetrios	●				
Kopetra	●		●	●	●
Mangia	●				
Skopra	●		●		
Spilios	●				
Mari–*Paliambela*	●				
Maroni–					
Petrara	●		●		
Vournes	●				
Zarakas	●				
Nicosia–*Ayia Paraskevi*	●				
Ora–*Palaeodhrapia*	●		●		
Pano Arkhimandritsa	●		●		
Paphos (kiln sites)			●		●
Peyia			●		
Pyla			●	●	
Sanida	●				
Tochni–*Lakkous*		●			
Zygi–*Petrini*	●				
Raw materials					
Akourdaleia			▲		
Dhrousha			▲		
Kellaki	■				
Mari (Kannaviou Fm)					⬢
Peyia			▲		
Sanida	■				
Varosia				▼	
Vasilikos Valley (Nicosia Fm)					⬢

compositional profiles for both the ceramics and clays (Glascock 1992). The combined compositional data have yielded unambiguous provenance determinations for Late Bronze Age and Roman pottery manufactured in the eastern Mediterranean, and the source assignments should ultimately afford a new perspective on the economy of Cyprus in late Antiquity.

METHODS

The ceramic samples were pulverized in an agate mortar after the slip and surface debris had been removed, and the clay samples were crushed after being air-dried. Small (200 mg) subsamples were taken from each powdered specimen and, following separation by dry sieving, from the <63 μm size fraction in the clay samples after they had been fired at 700°C for 1 h in an oxidizing atmosphere. The neutron activation analysis was undertaken at Missouri University Research Reactor (MURR), using a procedure involving two irradiations and three gamma counts that yielded determinations for 33 elements (Glascock 1992). All the basic data are archived at (and may be obtained from) MURR, and only summary data for the major compositional groups that we identify are presented here (Table 2). Principal components analysis provided the primary means of elucidating structure in the elemental data. Mahalanobis distance was used to calculate probabilities of membership in a given compositional group (Bishop and Neff 1989; Neff 1994). The clays provided compositional profiles for raw materials with which the ceramics were compared, but a source provenance was assigned to a compositional group only if the Mahalanobis distance for an extant clay sample placed it within the 1% probability cut-off. Evidence of provenance was also furnished by the presence of wasters derived from a kiln site or spatially inert ceramics within a compositional group, and by *post hoc* comparisons between our compositional groups and data for ceramics and clays analysed at the Brookhaven National Laboratory (BNL) and the Lawrence Berkeley Laboratory (LBL) (Bieber 1977; Gunneweg *et al*. 1983), accomplished using normalization procedures developed at MURR (Glascock 1992; Slane *et al*. 1994).

RESULTS

A quadripartite patterning emerged from the analysis (Figs 2 and 3), which is portrayed using 24 elements to facilitate comparison (Fig. 4) with LBL's compositional data for Late Bronze Age Biochrome wares from Enkomi (Gunneweg *et al*. 1993). WS, LR1C and C roof tiles each fall into separate compositional groups, and the fourth accommodates CRS, along with CS and the L roof tiles. The compositional groups are dominated by the named ceramics (Fig. 2, inset), which are both internally consistent and clearly differentiated. Principal components one and two subsume >80% of the total variance in the 24-dimensional data set, and Mahalanobis distances from each group centroid reveal no posterior misclassifications.

Residual clays associated with a highly weathered leucocratic gabbro (Gass *et al*. 1994) found adjacent to a site near the village of Sanida, where there is strong evidence for WS production (Todd and Hadjicosti 1991; Todd and Pilides 1993), exceed the 10% *p*-value cut-off for membership in the WS group (Fig. 2). A clay from Kellaki and normalized data (cf., Glascock 1992) for two clays from Kornos analysed at BNL (Bieber 1977) also both have an affinity with the WS group (Gomez *et al*. 1995; Gomez and Docherty 2000). Two clays from south-central Cyprus exceed the 10% *p*-value cut-off for membership in the LR1C group, as do two amphora wasters from a kiln site in Paphos (Karageorghis 1989) and Chalcolithic pottery from south-central Cyprus, which is presumed to have been manufactured in the local area (Rautman *et al*. 1993). A clay used by modern potters from the village of Varosia exceeds the 5% *p*-value cut-off for membership in the C roof tile group (Fig. 2). This compositional group also has an affinity with Late Bronze Age pottery from Enkomi (Fig. 4), which is inferred to have been made in that locale (Artzy *et al*. 1976; Gunneweg *et al*. 1983). The CRS(CS/L) group is linked to chromic luvisols (*terra rossas*) developed on Miocene-age reefal limestones that outcrop around the periphery of the Troodos Massif (King 1987; Follows 1992) by its light

Table 2 *Summary data for compositional groups, White Slip II (WS), Cypriot Red Slip (CRS), LR1C amphoras (LR1C) and Corinthian-style roof tiles (C); all data are in ppm, except for Fe, Al and Ca, which are expressed as percentages*

		As†*	*La*	*Lu*	*Nd†*	*Sm*	*U**	*Yb*	*Ce*	*Co*	*Cr*	*Cs*	*Eu*	*Fe (%)*	*Hf*	*Ni*†*	*Rb*
WS	Mean	3.191	8.106	0.332	8.023	2.262	0.942	1.928	17.324	40.791	303.1	0.686	0.706	7.04	1.882	120.8	14.8
	Std dev.	1.315	2.128	0.083	2.054	0.471	0.282	0.364	5.082	5.035	218.6	0.239	0.136	0.93	0.444	53.0	5.4
	Max.	6.667	15.983	0.548	14.382	4.358	1.580	3.119	39.591	54.152	1062.2	1.553	1.267	9.44	3.782	288.0	35.6
	Min.	1.770	3.411	0.181	3.095	1.418	0.407	1.164	7.773	25.128	69.4	0.282	0.493	5.45	0.941	45.4	0.0
	N	39	116	116	112	116	28	116	116	116	116	113	116	116	116	81	97
CRS	Mean	7.427	43.876	0.450	36.318	7.369	3.801	3.230	88.077	18.667	122.0	8.310	1.439	5.02	5.588	68.8	143.1
	Std dev.	2.399	4.005	0.033	3.627	0.686	0.648	0.278	8.322	1.547	20.6	0.664	0.135	0.34	0.689	19.8	10.2
	Max.	13.709	55.301	0.533	45.506	9.239	5.873	3.940	110.530	21.853	218.5	9.741	1.744	5.78	7.314	166.3	165.2
	Min.	1.289	35.924	0.374	28.000	5.573	2.465	2.693	70.243	13.848	77.7	6.505	1.054	4.06	4.335	33.4	120.0
	N	111	112	112	112	112	112	112	112	112	112	112	112	112	112	89	112
LR1C	Mean	5.951	12.495	0.255	11.439	2.908	1.820	1.702	24.337	28.314	1354.9	1.425	0.759	4.89	1.813	119.4	26.0
	Std dev.	1.815	1.421	0.020	1.638	0.238	1.799	0.212	2.893	4.737	1080.7	0.326	0.075	0.95	0.253	49.6	5.4
	Max.	10.223	15.208	0.286	14.000	3.462	10.072	2.033	30.706	37.281	4062.0	2.093	0.899	6.15	2.477	252.2	35.0
	Min.	3.259	8.882	0.205	8.195	2.453	0.833	1.173	17.224	16.808	96.5	0.703	0.549	2.42	1.396	54.4	13.7
	N	29	29	29	29	29	28	29	29	29	29	29	29	29	29	28	29
C	Mean	10.849	17.793	0.294	16.457	3.752	2.698	1.891	34.517	21.773	304.1	2.246	0.927	4.11	2.606	150.5	38.6
	Std dev.	2.959	1.071	0.025	1.913	0.266	0.841	0.155	1.980	3.274	37.3	0.852	0.059	0.46	0.200	29.1	10.2
	Max.	17.097	19.899	0.358	21.174	4.298	5.355	2.116	38.487	30.410	390.6	3.700	1.037	5.33	3.034	242.8	60.3
	Min.	4.487	15.938	0.252	11.483	3.278	1.583	1.495	30.488	15.541	227.6	1.073	0.797	3.29	2.187	111.7	21.1
	N	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38

Table 2 (*continued*)

		Sb†*	*Sc*	*Sr*†*	*Ta*	*Tb†*	*Th*	*Zn†*	*Zr*†*	*Al (%)*†*	*Ba**	*Ca (%)*	*Dy†*	*K*	*Mn*	*Na*	*Ti†*	*V*†*
WS	Mean	0.295	39.890	127.1	0.350	0.645	1.906	97.8	68.8	9.87	373	3.19	2.746	6012	1120	10861	3758	257.2
	Std dev.	0.115	4.010	60.9	0.100	0.182	0.599	39.7	13.4	0.94	695	0.98	0.555	2781	289	3968	863	40.8
	Max.	0.571	49.455	345.3	0.658	1.298	3.995	259.0	94.6	1.23	3166	6.06	5.080	24496	2086	23219	6320	381.3
	Min.	0.138	29.821	54.1	0.131	0.285	0.724	32.6	50.3	7.69	28	1.44	1.803	1931	633	5037	1935	180.5
	N	16	116	37	112	115	116	107	28	116	54	116	116	102	116	116	116	116
CRS	Mean	0.756	17.214	290.3	1.626	0.933	14.228	105.4	145.6	9.38	439	5.80	5.316	26848	701	5520	5216	141.4
	Std dev.	0.083	1.218	99.9	0.271	0.209	1.199	11.3	25.9	0.62	219	1.58	0.452	2114	119	1025	633	15.7
	Max.	1.123	19.176	529.0	2.418	2.137	16.987	158.1	216.4	1.06	1414	10.11	6.300	30966	1133	10019	7336	176.9
	Min.	0.543	12.988	130.4	1.188	0.478	11.265	83.8	99.2	7.21	187	2.38	4.147	21711	405	2912	3782	107.3
	N	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112
LR1C	Mean	0.490	24.099	720.5	0.414	0.562	2.561	88.8	64.9	5.02	312	16.19	2.761	8828	1206	7150	3330	186.1
	Std dev.	0.074	5.037	203.8	0.098	0.168	0.383	20.0	15.2	0.85	146	2.82	0.365	1241	208	2960	914	64.1
	Max.	0.694	32.538	1187.5	0.686	1.049	3.387	120.6	93.0	6.20	673	22.04	3.478	11013	1742	14762	5516	310.1
	Min.	0.361	14.338	354.2	0.268	0.364	1.611	49.9	46.0	3.10	57	12.81	1.638	6499	854	2806	1682	86.6
	N	29	29	29	29	29	29	22	21	29	29	29	29	29	29	29	29	29
C	Mean	0.646	17.370	685.3	0.558	0.740	4.785	76.6	80.7	5.68	370	16.41	3.172	12642	911	8664	3315	126.3
	Std dev.	0.116	2.273	152.6	0.044	0.236	0.343	10.7	17.3	0.57	286	1.19	0.293	3142	133	1666	371	15.5
	Max.	0.944	23.381	1036.8	0.657	1.408	5.586	111.6	122.1	7.40	1559	18.50	3.721	19005	1269	15129	4256	166.8
	Min.	0.385	13.356	303.8	0.468	0.430	4.199	61.0	46.0	4.63	134	14.33	2.419	4444	663	5664	2450	101.5
	N	38	38	38	38	36	38	37	38	38	38	38	38	38	38	38	38	38

*Elements excluded from comparisons with BNL data.
†Elements excluded from comparisons with LBL data.

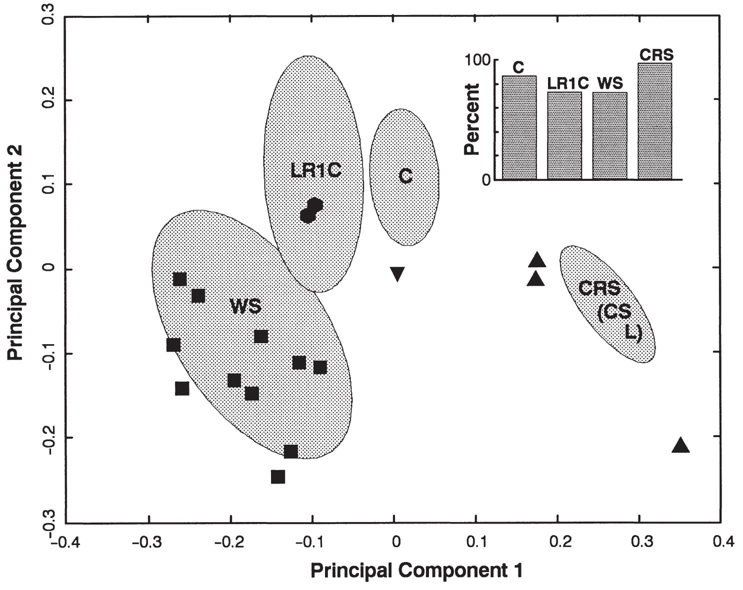

Figure 2 *Compositional groups for White Slip II (WS) and Cypriot Red Slip (CRS) pottery, LR1C amphoras and Corinthian-style (C) roof tiles differentiated using the first two axes extracted from a RQ-mode principal components analysis (Neff 1994) of a 24-element correlation matrix (N = 371). Ellipses define the 90% confidence level for each compositional group, and the coordinates of the clays that define its source provenance are plotted as solid symbols. Complete elemental data for the clays associated with the WS and CRS(CS/L) groups have been published previously (Gomez et al. 1995, 1996). Because the analytical procedure yielded data for only 21 elements (Bieber 1977), no BNL data are plotted. The inset shows the proportion of each compositional group consisting of named ceramics.*

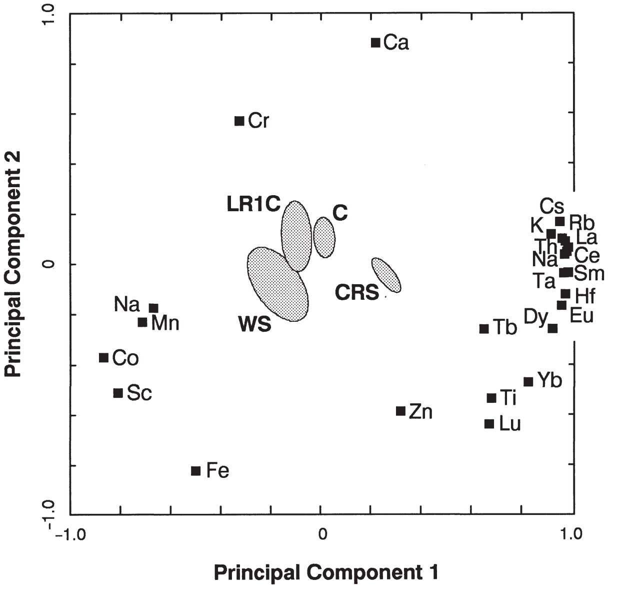

Figure 3 *A two-dimensional representation of the correlations among the 24 elements included in the principal components analysis. Depiction of the variables in this manner facilitates identification of the chemical basis for the separation between the compositional groups. For example, the CRS(CS/L) group is differentiated by enriched concentrations of most rare earth elements, and there is a distinction between high-Ca, low-Al (calcareous) and low-Ca, high-Al (non-calcareous) ceramics (Courtois and Velde 1980; Barlow and Idziak 1989), which differentiates the C roof tiles and LR1C groups from WS and CRS(CS/L).*

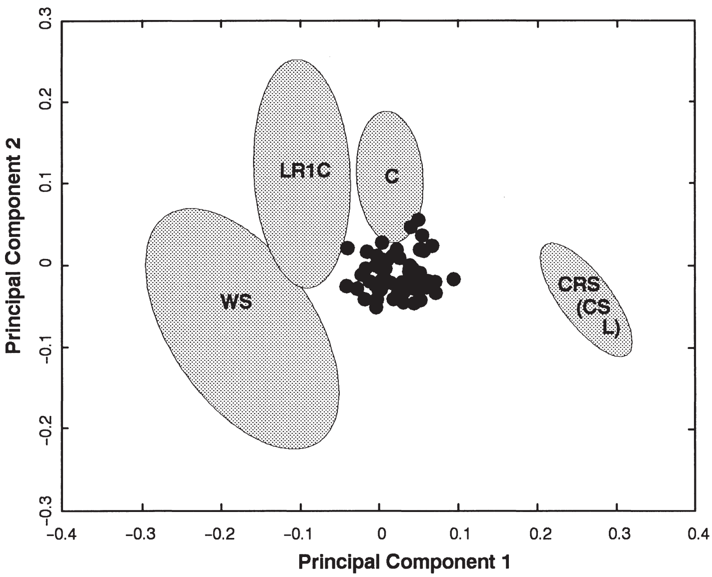

Figure 4 *A comparison between the C roof tile group and elemental data for Late Bronze Age Biochrome sherds analysed at LBL (Gunneweg et al. 1983). Three of the 61 sherds have a > 0.1% probability of membership in the C tile group, but all are excluded at the 1% level.*

rare earth element and Ca and Al composition (Fig. 3). Mahalanobis distance is least for three samples of the residual clay-rich soils in the region to the north of Paphos, but all of the samples fall below the 0.0005% *p*-value cut-off for group membership, because less Cs and Rb is characteristically present in the remnant soils than in the ceramics (Gomez *et al.* 1996).

DISCUSSION

WS was distributed throughout the eastern Mediterranean in the 14th and 13th centuries BCE, and the significance of its production perhaps lies in its links with the exploitation of copper ores, which underpinned the island's foreign relations in Antiquity (Courtois 1970; Popham 1972; Knapp and Cherry 1994; Gomez and Docherty 2000). Archaeological data point to a source provenance for WS within the Troodos Massif, and the pottery has a unique fabric that suggests derivation from basic or ultrabasic parent materials (Courtois 1970; Artzy *et al.* 1976; Courtois and Velde 1980; Todd and Hadjicosti 1991). All the WS sherds that we have analysed exhibit a similar composition (Gomez and Docherty 2000), and the links to raw materials that our data reveal explicitly indicate that sites on the southeastern flanks of the Troodos Massif yielded materials used to manufacture WS (Fig. 1). We caution that this does not constitute *prima facie* evidence for localized manufacture, since only one production site has been located (Todd and Hadjicosti 1991; Todd and Pilides 1993), and the affiliation of the Late Bronze Age cultural landscape with the island's mineral reserves remains a matter for debate (Keswani 1993, 1996). However, inasmuch as they provide evidence for a locally circumscribed economy that was based on the preferential exploitation of specific raw materials, the archaeological and chemical evidence are consistent with the postulated pattern of Late Bronze Age pottery production in adjacent regions (Henrickson and Blackman 1996).

CRS was manufactured from an homogeneous, fine-grained clay that lacks temper, but characteristically contains small detrital carbonate inclusions that erupt during firing and pit the surface (Hayes 1972). It circulated in the fifth–seventh centuries and was assigned to Cyprus on the basis of its prominence and typological variation in the local archaeological record (Hayes 1972; Jones 1986). There is a close physical resemblance between the fabrics of CRS and CS, and the compositional affinity between these two red-firing Roman wares confirms that CRS continued the tradition of fine ware production that began with the manufacture of CS in the first–third centuries (Hayes 1967, 1972). It also implies the consistent use of a specific raw material over a span of several centuries (Gomez *et al*. 1996). Although the clay used to produce CS was apparently levigated, we suggest that the aggregate differences in the quality of CS and CRS arose because the Roman artisans were compelled to use inferior clays that contained more impurities (cf., Hayes 1967, 1972), as their preferred clay sources became depleted over time. A regionalized pattern of resource exploitation is suggested by the distribution of the limestone outcrops that support remnant clay-rich soil in western Cyprus (Follows 1992). Either processing prior to firing or alteration during burial could have induced the compositional differences between the Roman fine wares and the extant clays (Freestone *et al*. 1985; Arnold *et al*. 1991), but they are most likely attributable to hydrochemical processes, which alter the amounts of alkali metals (including Cs and Rb) in weathering profiles over time (Brimhall and Dietrich 1987). The fine wares also have a compositional affinity with the L roof tiles, which appear to be the product of a well-organized, centralized industry rather than localized production (Rautman *et al*. 1999).

Our compositional data thus suggest that the raw materials used to produce CRS were derived from western Cyprus. This conclusion is consistent with archaeological arguments for CS production in the same region (Lund 1993). The time-transgressive link between CS and CRS, taken in concert with the compositional affinity of these fine wares with the L roof tiles, implies that western Cyprus was home to a major ceramic industry in Roman times. Fine pottery vessels of specialized shape and decoration lend themselves to long-distance exchange, and WS, CS and CRS wares came to dominate many regional markets (Hayes 1972; Popham 1972; Lund 1997). The larger size and greater weight of roof tiles present serious obstacles to their transport over great distances. It is thus not surprising to find, on Late Roman Cyprus, the development of two contrasting traditions of roof tile manufacture based at opposite ends of the island: one in the vicinity of Paphos and the other near Salamis-Constantia (Figs 1, 2 and 4).

As noted by Rautman *et al*. (1999), and in common with other ceramic assemblages from Cyprus (Barlow and Idziak 1989), the four groups that we recognize separate into low-Ca, high-Al (non-calcareous) and high-Ca, low-Al (calcareous) compositions (Fig. 3). The L roof tiles (in common with CS and CRS) fall into the former category, whereas the C roof tiles, which have a physical appearance that is consistent with the characteristics of the calcareous sediments that outcrop across the Mesoria Plain (Rautman *et al*. 1993; McCallum and Robertson 1995), fall into the latter. As the proximity of the C roof tiles and the Late Bronze Age pottery analysed at BNL in multivariate compositional space suggests (Fig. 3), the ceramic industry in eastern Cyprus has a long history of using these materials. The calcareous C roof tile and LR1C groups are also closely related in compositional space (Figs 2 and 4). However, our data indicate that the LR1C amphoras were produced within the hinterlands of the Roman ports of Amathus and Paphos (Fig. 1). Similar LR1-style amphoras have been linked with the expansion of trade in olive oil and wine during the fifth–seventh centuries, and are known to have been manufactured in multiple fabrics on sites throughout the eastern Mediterranean (Williams 1987; Empereur and Picon 1989). Abundant, (sub)rounded, sand-sized, igneous inclusions present throughout the body represent temper added to the fine-grained calcareous clay, and give the surface of the ceramics in the LR1C group a distinctive rasp-like texture (Rautman *et al*. 1999). These inclusions, which are predominately derived from the ultrabasic and basic rocks of the Troodos plutonic complex, with minor contributions from the diabase, imply a link to rocks exposed on the southern flanks of the Troodos Massif (Gass *et al*. 1994). The compositional similarity between the two geographically distinct production areas may arise because the Kannaviou Formation (Robertson 1977), which yielded a clay that exceeded the 53% *p*-value cut-off for membership in the LR1C group, outcrops in both south-central and south-west Cyprus. But it is also possible that a larger sample of ceramics from the Paphos region will allow us to separate the kiln wasters, which lack pyroxene inclusions, from the amphoras exclusively in south-central Cyprus. The latter contain abundant pyroxene inclusions, and are consequently distinguished (although not presently discriminated) by their elevated Cr, Ti and Ni concentrations.

Although the exact sources of the clays used to manufacture these ceramics and the locations of most workshops remain uncertain, several clays are associated with formations that have a spatially restricted, regionalized distribution. These raw materials probably underwent little refinement, because the essential chemical and physical characteristics of the clays persist in the pottery (cf., King 1987); for example, the presence of aplastic material in WS and its absence in CS and CRS (Hayes 1967; Popham 1972). Furthermore, the structure of our compositional groups, which transgresses the boundaries of individual sites, supports the argument that these clays were preferentially selected because of their ability to impart particular aesthetic standards to finished wares (Bieber 1977; Barlow and Idziak 1989; Vaughan 1991; Glascock 1992). It suggests a sophisticated tradition of regional pottery production in Antiquity, one that relied on the exploitation of distinctive, but widely available, raw materials.

CONCLUSIONS

We have demonstrated that by systematically analysing finished products and raw materials, it is feasible to link ancient pottery and extant clays—although this may not always be possible, since raw materials are often mixed during pottery production and the paste is commonly levigated or tempered. The success of our analysis is predicated on the preservation of chemical linkages between the raw materials and finished wares, and implies that the exploited deposits were workable in their original form. By adopting an ecumenical approach to sample selection, it appears to be possible to resolve the source provenance of pottery with some confidence. This suggests that compositional analysis may well provide the means to assemble geographies of pottery production, since a better appreciation of the spatial aspects of commodity exchange can be gained if imported pottery can be linked to its site of manufacture. The ability to specify a source provenance for both fine wares and functional ceramics is, however, founded on surveys of raw materials that extend far beyond the bounds of individual archaeological sites. Our investigation affords a new perspective on provenance studies of ancient pottery by providing direct physical links between four groups of formally distinct Cypriot ceramics and the clays used in their production. The distribution of probable clay sources and the link between pottery styles and the material environment together imply that ceramic manufacturing was organized on a regional basis. The varied sources of these selected wares correlates with our understanding of the basic geographical and historical structure of the island’s economy. WS manufacture appears to be related to large-scale copper extraction in mountainous inland parts of the island during the Late Bronze Age. The primacy of Paphos as the main port and urban centre of

Roman Cyprus may underlie the emergence of CS in the first–second centuries CE, as well as the CRS and L roof tile successor industries. The development of Salamis-Constantia as the island's capital in the fourth century would have encouraged roof tile production in the area. As containers of perishable agricultural commodities, LR1C amphoras were made as close to the productive hinterland as possible and, indeed, the variability of analysed specimens suggests that they came from multiple locales. The evidence provided by these ceramic products reinforces the association with large regional centres (such as Salamis-Constantia, Paphos and Amathus) that is required to delimit interaction zones for individual archaeological sites and unravel the interregional system of exchange that operated in Antiquity.

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