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Archaeology

INAA OF MINOAN CERAMICS FROM KOMMOS, CRETE

R. G. V. HANCOCK,* P. P. BETANCOURT**

**SLOWPOKE Reactor Facility and*
Department of Chemical Engineering and Applied Chemistry,
University of Toronto, Toronto,
Ontario (Canada) M5S 1A4
***Department of Art History,*
Temple University,
Philadelphia, PA 19122 (USA)

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Ninety-two samples of ceramics from Kommos in south-central Crete, covering the Middle Minoan periods MMI to MMIII have been analyzed by instrumental neutron activation using the SLOWPOKE reactor at the University of Toronto. The sherds represented three basic fabric types: a fine buff fabric, a stone tempered buff fabric, a coarse, stone tempered red fabric. Also included in the study were three sherds from nearby archaeological sites and six Kommos sherds which were archaeologically assessed as exhibiting atypical fabrics. The three fabric types were sortable into two distinct chemical groups, and two similar groups. Little temporal variation in chemical composition was found in the fine buff wares, and the atypical fabrics fitted neatly into three of the chemical groups.

Introduction

Although ceramic materials from Crete have been analyzed by a number of researchers (1-6), very little attention has been paid to the prehistoric Minoan site of Kommos.

Kommos is located in south-central Crete along the shore of the Messara plain beside the Libyan Sea. The two famous Minoan sites of Aghia Triada and Phaistos are located inland to the northeast approximately 8 km.

Ninety-eight ceramic samples were obtained from the Kommos excavations which are directed by Professor J.W. Shaw of the University of Toronto. These ceramic samples included material representing the Middle Minoan (MM) period which lasted from approximatley 2000 BCE until 1700 BCE. [As an archaeological

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Akadémiai Kiadó, Budapest

aside, three small ceramic samples were obtained from Phaistos (1) and Aghia Triada (2) for a preliminary comparison with the Kommos material.] Included in the Kommos group of sherds were six sherds listed archaeologically as miscellaneous. This group consisted of overfired and atypical fabrics.

All sherds fell into one of three broad archaeological categories:

1. a fine buff fabric made of untempered or very slightly tempered clay, used for cups and other fine shapes.
2. a stone (pebble) tempered version of the buff ware, used for jugs, jars and thicker shapes.
3. a coarse red ware including varying amounts of stone (pebble) temper, and used mainly for cooking pots and dishes.

Samples from this group of sherds were subjected to neutron activation analysis in an attempt to establish inter- and intra-group variations in chemical composition, and to assess temporal and geographical differences or similarities.

Sampling and chemical analysis

For most sherds, there was enough material to produce samples of 200-400 mg for chemical analysis, with some samples as low as 80 mg. However, only small samples were available from Phaistos (21 mg) and Aghia Triada (8.5 and 68 mg), making them somewhat more difficult to analyze.

Samples were taken from the body of each sherd after the removal of surface material by carborundum bit abrasion.

Coarse chips of sherd were used in the analysis. Concentrations of thirty-four elements were determined using the INAA procedure developed by Hancock (7,8) with increased neutron bombardment used, whenever possible, on the smaller samples. From the analyzed elements, the major elements Na, Mg, Al, Ca, and Fe, and the minor and trace elements V, Cr, Mn, Co, Ni, As, Sr, Cs, Hf, Ta, and Hf have been selected for this paper to establish intra-and inter-group similarities and differences.

Results and discussion

Local Versus 'Foreign' Wares

The group means and standard deviations of the above sixteen elements for the three archaeologically classified groups of Kommos sherds are displayed in Table 1. Note that the coarse red ware is divided into two distinctly different chemical groups, the second of which is tentatively labelled "foreign". This implies that the sherds are foreign to Kommos and possibly, but not necessarily, foreign to the Messara plain and even to Crete itself. These four foreign sherds are readily separable chemically from the twenty-seven other red sherds by their low Na, Mg, Ca, Mn, Cr, Co, and Ni and by their high As, Ta, and Th concentrations.

The tempered buff wares and the fine buff wares are clearly separable from the coarse local red wares, using Mg and Ca (and perhaps Sr and Cs). Many of the other elements exhibit differences in the group means, but the group concentration distributions overlap broadly, even at the 67% (1 σ) confidence level (e.g., V, Fe, Co, Ni, Hf).

Table 1
Kommos pottery concentration profiles

Element	Coarse Red (27 samples)	'Foreign' Red (4 samples)	Tempered Buff (31 samples)	Fine Buff (36 samples)
Na%	0.91 ± 0.22	0.55 ± 0.04	0.93 ± 0.22	0.80 ± 0.10
Mg%	1.8 ± 0.5	0.8 ± 0.2	3.4 ± 0.6	3.1 ± 0.6
Al%	7.96 ± 0.95	9.41 ± 0.75	7.64 ± 0.58	8.20 ± 0.82
Ca%	1.75 ± 1.24	0.65 ± 0.50	5.77 ± 1.89	6.84 ± 1.92
V	128 ± 20	132 ± 4	141 ± 15	134 ± 21
Cr	396 ± 76	115 ± 16	479 ± 102	391 ± 38
Mn	979 ± 406	351 ± 148	858 ± 175	922 ± 120
Fe(%)	5.11 ± 0.46	5.30 ± 0.76	5.15 ± 0.39	5.62 ± 0.82
Co	27.9 ± 3.9	15.9 ± 4.2	33.3 ± 4.9	31.4 ± 3.2
Ni	169 ± 54	<60	241 ± 62	233 ± 51
As	8.7 ± 3.7	20.4 ± 1.2	9.8 ± 11.5	9.3 ± 6.9
Sr	190 ± 40	140 ± 30	320 ± 80	330 ± 90
Cs	5.4 ± 1.5	4.7 ± 0.7	7.5 ± 1.2	9.0 ± 2.2
Hf	4.7 ± 1.0	6.9 ± 0.7	3.2 ± 0.4	3.9 ± 0.4
Ta	1.2 ± 0.3	2.1 ± 0.4	1.0 ± 0.1	1.3 ± 0.2
Th	9.5 ± 2.3	12.3 ± 1.7	8.4 ± 0.8	9.8 ± 1.5

The buff wares, fine and stone-tempered, are much more difficult to separate. Both are calcareous wares varying from 3-10% Ca, and suggesting that the tempering materials are responsible for the observed variations in chemical composition.

To test this idea, three tempered buff fabric sherds were coarsely crushed and "clay", pebbles, and other inclusions extracted with tweezers. Analysis of these small subsamples produced the data displayed in Table 2.

The relatively low Ca sample T189 produced two inclusions with compositions quite different from the clay. The pebble had high Na and low Mg, Ca, V, and Mn relative to the clay and the grit sample was low in all measured elements.

Sample T-201, which was also low in Ca, gave two different types of inclusion, the first being Na rich, and Mg, Ca, and V poor, and the second looking chemically and visually

Table 2
Clay and inclusion analyses for three tempered buff sherds

Sherd T-189	Clay (4 samples)	Pebble	Grit
Na%	0.91 ± 0.04	2.37	0.70
Mg%	2.4 ± 0.5	<1.0	1.0
Al%	6.35 ± 0.93	7.03	3.31
Ca%	3.18 ± 0.31	0.75	1.4
V	115 ± 9	22	47
Mn	583 ± 161	110	271

T-201	Clay (3 samples)	Pebble	10 Small Inclusions	White Inclusion
Na%	1.00 ± 0.05	1.13	1.42	0.064
Mg%	2.8 ± 0.3	0.89	1.7	<0.25
Al%	7.32 ± 0.50	6.24	6.01	0.73
Ca%	3.24 ± 0.76	0.37	1.87	<0.07
V	130 ± 7	75	100	4
Mn	537 ± 52	423	666	11

T-203	Clay (5 samples)	Grit	Grit
Na%	1.23 ± 0.02	1.17	1.17
Mg%	3.3 ± 0.3	3.5	3.1
Al%	7.00 ± 0.30	7.88	6.47
Ca%	8.87 ± 0.21	9.86	7.74
V	138 ± 9	155	102
Mn	814 ± 33	745	696

like dirty quartz. Sample T-203, with high Ca, exhibited grit samples which had chemical compositions, for the elements measured, similar to the clay itself.

Therefore, the three different sherds produced 5 different chemical types of inclusions. Small quantities of these (and other) inclusions may therefore be expected to alter significantly the concentrations of many elements.

The relatively high concentrations of Mg, Cr, Ni, and Co found in the main groups of Kommos wares probably indicates that the erosion products from a Mg rich soft stone form a

significant component of the local Messara plain clays from which these ceramics were made.

Also, the archaeological classification of coarse red wares as cooking pots and dishes, fine buff wares as cups and tempered buff wares as jugs and jars fits well with the chemistry of these different ceramics. The low Ca, red burning clay could well be expected to have a much lower coefficient of expansion than the buff ware and might therefore be more thermally resistant than the buff ware with its relatively high calcium concentrations. This may imply a careful selection of raw material by prehistoric Minoan potters to suit the usage of their products.

It is of interest to note that the coarse red ware has a lower average Fe concentration than the buff wares. The red to buff colour difference probably arises from the high calcium content of the buff wares (9).

Miscellaneous

The chemical analysis data for the six miscellaneous sherds from Kommos and one each of the sherds from Phaistos and Aghia Triada (the small 8.6 mg sample gave too many concentration detection limits to be useful in this discussion) are shown in Table 3.

Column 1 gives the group mean and standard deviation for 3 red sherds which are chemically similar to the coarse red ware group.

Column 2 shows the group mean and standard deviation for 2 red sherds which help form the "foreign" group.

Table 3
Chemical concentration profiles for "miscellaneous" sherds

	Miscellaneous Red (3 sherds)	A Typical Red (2 sherds)	Atypical Fine Buff (1 sherd)	Aghia Triada (1 sherd)	Phaistos (1 sherd)
Na%	0.92 ± 0.21	0.53 ± 0.03	0.81	0.71	0.90
Mg%	1.6 ± 0.5	0.8 ± 0.4	2.4	3.1	4.2
Al%	8.31 ± 0.83	10.0 ± 0.2	7.63	7.23	8.02
Ca%	0.96 ± 0,32	0.6 ± 0.2	5.95	5.35	5.63
V	122 ± 33	131 ± 5	124	142	145
Cr	497 ± 74	122 ± 17	334	543	440
Mn	773 ± 183	378 ± 127	1040	800	981
Fe%	5.54 ± 0.44	5.31 ± 1.30	4.88	5.79	5.77
Co	29.2 ± 6.7	17.1 ± 3.8	27.2	35.8	39.9
Ni	209 ± 68	⩽ 60	153	223	347
As	6.6 ± 1.5	20.0 ± 1.7	6.7	4.8	5.9
Sr	170 ± 30	120 ± 20	250	310	⩽740
Cs	5.4 ± 2.8	5.3 ± 0.3	6.3	7.4	8.1
Hf	4.6 ± 0.6	7.4 ± 0.6	3.9	3.4	4.0
Ta	1.2 ± 0.2	2.0 ± 0.7	1.0	0.6	0.7
Th	8.9 ± 1.6	13.5 ± 2.1	8.6	8.9	8.6

Column 3 displays the results for sherd T-183, part of a lamp, which looks similar to the buff ware composition.

Columns 4 and 5 show the data for the single sherds from Phaistos and Aghia Triada. Although analysis of one sherd is certainly insufficient to characterize masses of material from a site, it is encouraging to note the similarities between the Phaistos sherd, the Aghia Triada sherd, and the buff fabric materials from Kommos.

Temporal Differences in Fine Buff Ware Sherds

The fine buff fabric sherds cover a period of approximately 300 years from MMIB through to MMIII. Even though the sherd selection concentrated on the MMIII period, there are probably enough earlier sherds (10) to give one a tentative idea about the temporal chemical similarities or differences in this ware.

Table 4
Chemical concentration profiles of fine buff fabric sherds

	MM IB-IIA (2 sherds)	MMII (6 sherds)	MMII-III (2 sherds)	MMIII (25 sherds)
Na%	0.94 ± 0.11	0.83 ± 0.13	0.80 ± 0.10	0.79 ± 0.10
Mg%	3.3 ± 0.7	3.2 ± 0.4	2.5 ± 0.5	3.1 ± 0.6
Al%	8.05 ± 0.44	8.29 ± 0.58	8.21 ± 0.74	8.21 ± 0.90
Ca%	4.91 ± 1.82	7.01 ± 1.96	7.53 ± 1.43	6.85 ± 2.00
V	133 ± 24	117 ± 18	130 ± 6	139 ± 21
Cr	496 ± 170	402 ± 24	378 ± 50	392 ± 41
Mn	967 ± 101	925 ± 99	1000 ± 55	914 ± 132
Fe%	5.55 ± 0.45	5.69 ± 0.40	5.57 ± 0.64	5.62 ± 0.42
Co	34.2 ± 4.9	30.9 ± 3.4	30.2 ± 2.6	31.7 ± 3.2
Ni	251 ± 69	240 ± 47	213 ± 63	237 ± 53
As	10.4 ± 3.4	15.6 ± 12.0	7.6 ± 0.9	7.7 ± 5.0
Sr	250 ± 50	340 ± 80	300 ± 50	340 ± 100
Cs	6.5 ± 0.5	9.2 ± 2.0	8.0 ± 2.0	9.1 ± 2.3
Hf	3.5 ± 1.0	4.1 ± 0.3	4.0 ± 0.3	3.9 ± 0.4
Ta	1.2 ± 0.3	1.5 ± 0.2	1.2 ± 0.2	1.2 ± 0.2
Th	8.5 ± 1.4	9.7 ± 0.7	10.0 ± 0.2	9.9 ± 1.0

The data are presented in Table 4, and show a remarkable degree of consistency, given the relative paucity of samples. (The anomalous As data for the MMII sherds in column 2 comes mainly from a distortion by two samples: T-149 with 22.4 mg/kg As and T-163 with 37.3 mg/kg As - source unknown).

Conclusions

This attempt to establish some of the chemical concentration profiles of Middle Minoan ceramics found at Kommos has confirmed the presence of two chemically dissimilar red fabrics (one common and presumed local), and two chemically similar tempered and fine buff fabrics.

Of the four foreign red sherds only two were classified archaeologically as being atypical. Conversely, visual inspection of the buff wares rapidly split the sherds into two usage groups - fine wares (cups, etc.) and coarser wares (jugs

and jars, etc.) whereas sophisticated chemical analysis procedures up to now could not do this nearly as well, if at all.

The use of low calcium (red firing) clays for cooking, and more calcareous (buff firing) clays for table and storage wares may well indicate the original potters' intelligent usage of different local clay sources.

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