LATE BRONZE AGE POTTERY FABRICS FROM THE BAQᶜAH VALLEY, JORDAN: COMPOSITION AND ORIGINS

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Introduction

Relatively few studies of pottery technology and provenience (*e.g.*, Rands *et al.* 1974) have taken advantage of the mutually complementary nature of archaeological, petrographic, and elemental analyses, although such an approach has often been recommended (Shepard 1965; Peacock 1970; Harbottle 1976). Standard typological characterization is needed to make sense of any large collection of pottery. Thin-section mineralogical study takes this one step further by revealing microscopic evidence for manufacturing techniques (levigation, tempering, *etc.*). The latter is also the *sine qua non* for quantitative chemical techniques, since inhomogeneities in the fabric, amount and type of temper, leaching and depositions of salts, and other factors that significantly alter elemental concentrations of the native clay can be assessed and possibly corrected for.

In recent years a very extensive and representative collection of Late Bronze Age (LBA) imported and presumed local pottery has been recovered from burial caves in the Baqᶜah Valley, Jordan (McGovern 1980, 1981a). A group of fourteen sherds, representing four main types of pottery—Mycenaean IIIB, Base-Ring II, Chocolate-on-White/White Slip, and presumed local: see Plate 1—were selected from this collection for a pilot study of the structure, composition, and provenience.

Petrography

Twelve sherds were thin-sectioned, and the petrographic characters determined with reference to the following eight parameters: percentage of different inclusions, mean diameter and size frequency distribution of 100 randomly selected grains, fabric and slip colors, and the presence/absence of shale, calcite, and temper. In order to assess the quality of raw materials available to ancient potters, eight clay and six sand/sandstone samples, collected from different sedimentary environments in the Baqᶜah Valley, were also examined.

Average diameter and size distribution of mineral inclusions proved to be the most sensitive indicator in defining groups. While grains in the Mycenaean and Cypriote sherds were almost exclusively silt-sized (0.039 - 0.062 mm), 60 - 80% of the inclusions in the presumed local sherds were in the sand range (0.062 - 2.00 mm). The Chocolate-on-White and White Slip examples had an intermediate distribution, 30% of the inclusions falling into the sand-sized fraction.

The mineralogy of the collection was extremely nondescript. Quartz was the main inclusion in all the sherds, but was considered as temper only where it comprised more than 5% of the fabric volume (Rye 1976), as in the case of the Chocolate-on-White wares (BQ9 and 10: estimated at up to 8%) and presumed local wares (BQ11 -14: estimated at up to 7%). Eight additional minerals, although quite negligible, were identified: colorless amphibole, biotite, calcite, green hornblende, basaltic hornblende, muscovite, plagioclase, and sphene. Organic tempering was evidenced by straw impressions on two presumed local sherds (BQ11 and 14). For the untempered sherds, the Base-Ring II pieces (BQ5 - 7), with about 1% mineral inclusions (including shale), could be distinguished from the Mycenaean pieces (BQ1 - 4) since the latter contained only about 0.1% mineral inclusions (no shale).

The consistently high standard of all the LBA wares is best explained by intentional levigation, since clay beds are rarely homogeneous, even over short distances (Weaver 1963). For predominantly limestone terrains, greater amounts of calcite, either as a residuum in the clay or as temper, are usually observed.

An examination of the clay samples from the Baqᶜah, a limestone/sandstone alkaline environment, revealed that they were remarkably free of primary calcite, in no instance more than 1%. Microcrystalline secondary calcite, which cannot be removed by washing, was also virtually non-existent. The clays were very simple mineralogically; the non-clay fraction was composed almost entirely of quartz with trace amounts of calcite, green hornblende, magnetite, and pyrolusite. However, the absolute percentage of inclusions varied between 1% and 70%, so that levigation would definitely have been required to remove inhomogeneities and to ensure clay purity.

The sand/sandstone samples we examined showed very little calcite contamination so the Baqᶜah potter would also have had little difficulty in procuring very pure temper. The sands had come from a mature sedimentary environment: the quartz grains were well-rounded, like those in the presumed local sherds. Trace minerals were limited to occasional grains of green hornblende and black opaques.

Hierarchical aggregative clustering (Fig. 1 a and b) of the petrographic characters using the computer algorithm UPGMA (unweighted pair-group method by arithmetic averages; Sneath and Sokal 1973) generally confirmed the

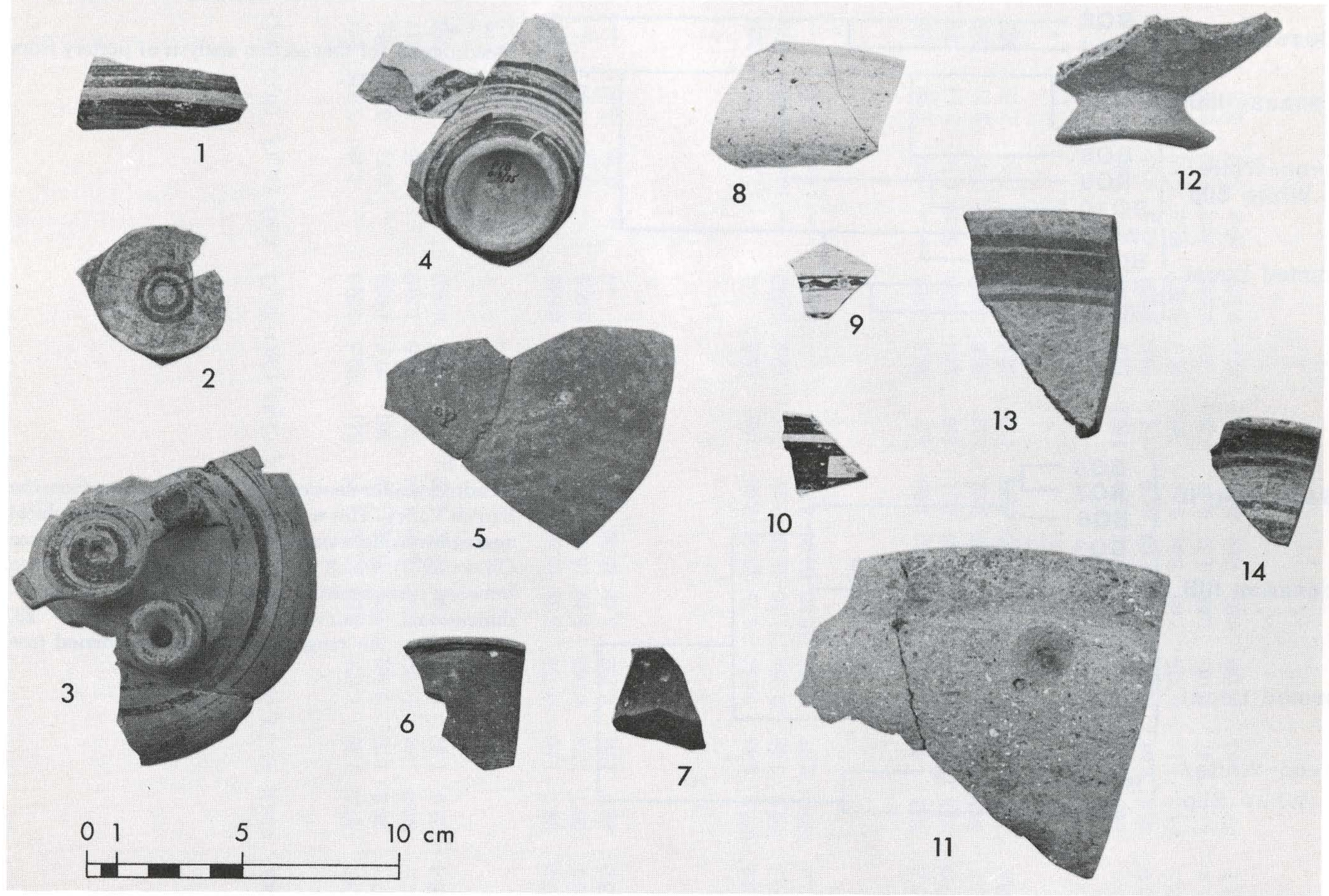

Plate 1: LBA Pottery types from the Baqᶜah Valley:

BQ1-4: Mycenaean IIIB wares.
(Field numbers: 26A-1, B3-37, B3-34 and B3-103.)
BQ5-7: Base-Ring II wares.
(Field numbers: I, 51-3, and 45-23.)
BQ8: White slip ware.
(Field number: 66-28.)
BQ9, 10: Chocolate-on-White wares.
(Field numbers: 58-1, 66-27.)
BQ11, 12: Undecorated, presumed local wares.
(Field numbers: 53-44, 47-13.)
BQ13, 14: Bichrome, presumed local wares.
(Field numbers: 66-9, 65-6.)

Note: BQ2-4 were recovered during the 1978 general field survey. The remainder of the sherds were recovered during the 1977 excavation of Cave A2.

archaeological groupings. However one White Slip sherd (BQ8) deviated from archaeological expectations, being closer to the Mycenaean than to the Chocolate-on-White examples. This discrepancy resulted largely from considering the inclusions (3%) in that sherd as naturally occurring, even though the working properties of some clays can be improved by adding temper in amounts less than 5%. A random variation of several per cent may actually reflect the degree of levigation rather than the deliberate withholding of temper.

Neutron Activation Analysis (NAA)

Since the primary mineral inclusion, quartz, generally acts as a dilutant for the elements measured by NAA (Harbottle 1970), thoroughly mixed, 200 mg. samples were considered representative of the overall fabric (Bromund *et al.* 1976). Sampling procedures (by both drilling and powdering), and irradiation procedures followed those described in Abascal *et al.* 1974 and Bieber *et al.* 1976. The resultant data were processed by a series of computer programs, incorporating decay corrections, spectrum analyses, and USGS standards, which led to a final printout of the concentration of twenty-three elements for each sherd (see Table 1).

Significant deviations of some elements (most obviously sodium, potassium, rubidium, calcium, and barium) are common in a limestone environment where salts are being leached out and redeposited. Variation in other elements (*e.g.*, lanthanum, manganese, samarium) is unexplained.

Although over-simplified and uncorrected for possibly significant factors (for example, covariance between elements), the NAA dendrogram clearly substantiates the stylistic groupings for the Baqᶜah wares. Two pairs of Mycenaean IIIB specimens merge, and are most similar to the very tight group of Base-Ring II sherds. The presumed local

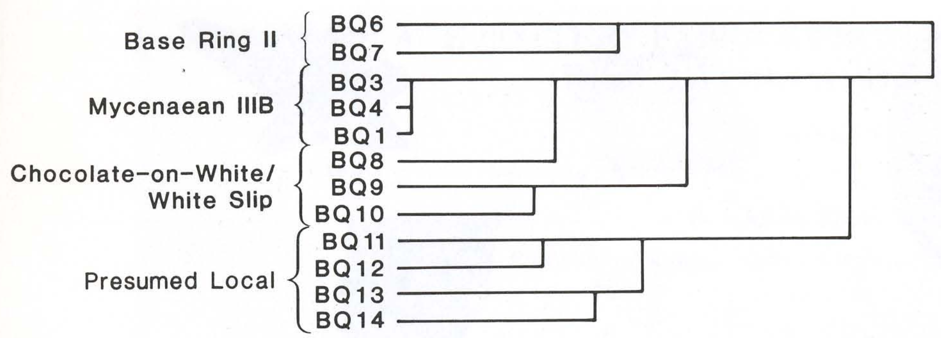

Fig 1 a:
Dendrogram for thin section analysis of pottery from the Baqʿah Valley.

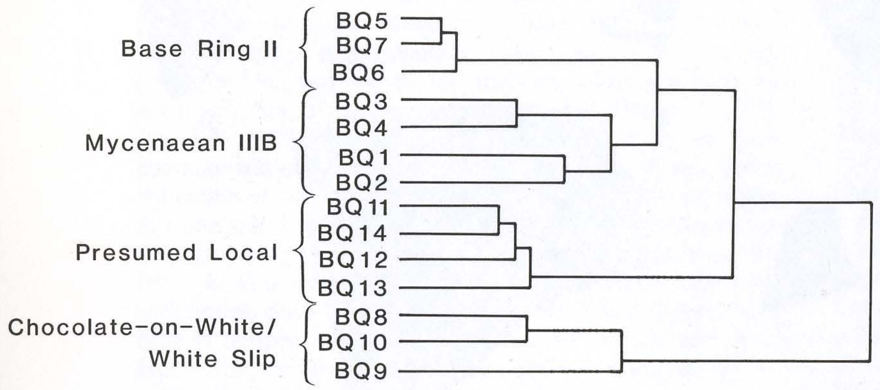

Fig. 1 b:
Dendrogram for neutron activation of pottery from the Baqʿah Valley. This was generated using a hierarchical aggregative clustering algorithm (AGGLUS, type 3: see Olivier 1973), which minimizes the Euclidean distance between the centroid and data points in an n-dimensional framework. In this case n = 23, representing the range of elements determined (see Table 1).

sherds bunch together, but the Chocolate-on-White and White Slip samples stand well apart from the other groups.

In the hope of establishing specific proveniences, a computer search program next compared the Baqʿah samples with the Brookhaven data bank of world-wide ceramics in which various regions of the Mediterranean and Near East are well-represented. A "match" occurred when a sample had no more than two elemental concentrations outside a 20% logarithmic range of the Baqʿah sherd which was being compared.

The computer search produced some significant results. BQ1 and BQ2 only matched samples from a relatively small area of the northeastern Peloponnese, Attica, and Boetia, including nine specimens that belonged to Berbati subgroups 1 and 3 (Bieber *et al.* 1976) of the Oxford "Composition A" group (Catling *et al.* 1963). In contrast, the other pair of Mycenaean IIIB sherds completely lacked matches, probably resulting from elemental variations in alkali metals and earths. The thorium/hafnium ratio, an especially sensitive indicator, supports a Mainland Greek origin for all the Mycenaean IIIB samples.

The Base-Ring II sherds (BQ5 - 7) matched a large number of samples, which were distributed over a large geographical area, including Cyprus, central Mainland Greece, Crete, Palestine, and Iran. However, the ten matches from outside Cyprus were not particularly significant because of less precise dating and/or archaeological criteria. Several were modern clay samples (Athens and Vasiliki), which are sometimes dissimilar to fired wares (Bieber *et al.* 1976; Peacock 1970). On the other hand, widely separated clay beds in the Mediterranean basin can be virtually chemically identical because of similar geological origins.

The nineteen matches from Cyprus came from the northeastern coast (Melissa and Vounari near Phlamoudhi) and the center of the island (Idalion). Nine samples that clustered with a northeastern coastal subgroup (Phlamoudhi 1) were an important common denominator in establishing a probable origin for the Baqʿah sherds (Bieber *et al.* 1976). The Phlamoudhi specimens (Late Cypriote I Red-on-Black and Monochrome) are also comparable in date to BQ5-7.

BQ8-14, the Chocolate-on-White/White Slip and presumed local groups, had no matches. As the first Brookhaven study to incorporate central Transjordanian plateau material, the negative evidence did not at least contradict working hypotheses that these wares were of local origin.

Definitive evidence, however, for the provenience of the presumed local wares was provided by recent NAA of Baqʿah clay samples. Whereas five clays (BQ33, 35-37) from different areas of the valley clustered separately, one sample (BQ32) from the wadi below the settlement site (Khirbet Umm ad-Danānīr), associated with the burial caves, was very close chemically to the presumed local sherds (see Table 1).

Table 1: Concentration of elemental constituents.

NAA No.	Major (%, by weight)					Minor (ppm, by weight)																	
	Na_2O	K_2O	Fe_2O_3	MnO	CaO	Rb_2O	Cs_2O	BaO	Sc_2O_3	La_2O_3	CeO_2	Eu_2O_3	Lu_2O_3	HfO_2	ThO_2	Ta_2O_5	Cr_2O_3	CoO	Sb_2O_3	ZnO	Sm_2O_3	Yb_2O_3	SrO
Mycenaean IIIB																							
BQ1	0.517	1.460	7.55	0.123	13.90	153.0	12.30	672	35.0	33.2	67.5	1.49	0.656	3.22	12.30	1.15	311	39.5	0.916	—	6.46	3.30	274
BQ2	1.290	1.740	8.59	0.120	10.10	130.0	11.20	425	39.6	37.1	76.2	1.59	0.561	3.66	13.70	1.17	361	37.5	1.920	—	6.71	3.48	351
BQ3	1.880	0.870	7.96	0.118	11.60	50.2	10.40	316	37.2	47.1	92.0	1.44	0.554	3.97	12.70	1.24	354	38.0	1.310	—	6.45	3.56	417
BQ4	1.690	0.871	8.20	0.110	11.80	61.9	12.40	353	38.1	56.4	131.0	1.47	0.652	3.37	12.40	1.12	374	39.1	0.593	—	6.23	3.23	399
Base Ring II																							
BQ5	0.700	3.150	7.26	0.113	3.73	153.0	9.11	449	29.7	45.2	94.7	1.80	0.756	5.38	15.60	1.74	176	25.5	0.848	—	8.06	3.84	325
BQ6	0.871	3.220	7.34	0.149	3.72	158.0	9.62	465	30.2	46.1	96.7	1.74	0.682	5.19	15.50	1.73	197	29.6	0.922	—	8.51	3.90	—
BQ7	0.663	2.980	7.06	0.113	4.49	148.0	8.75	362	29.2	45.0	92.9	1.84	0.732	5.12	15.30	1.81	167	25.9	—	—	8.30	3.84	—
Chocolate-on-White/ White Slip																							
BQ8	0.224	1.090	3.70	0.009	3.20	53.9	8.28	455	34.6	78.2	187.0	2.46	0.854	9.75	28.00	3.06	186	18.9	—	—	11.50	5.52	329
BQ9	0.228	3.050	3.57	0.005	1.58	96.8	8.74	324	34.3	59.2	150.0	3.22	0.954	11.10	22.80	2.46	163	12.2	0.462	—	14.10	5.96	279
BQ10	0.237	1.110	3.46	0.019	—	75.1	7.54	292	29.6	71.4	158.0	2.37	1.100	10.60	26.00	4.88	184	—	0.481	—	11.40	5.37	—
Presumed Local																							
BQ11	0.240	1.900	5.73	0.046	14.50	73.6	4.08	245	26.8	26.8	59.1	1.43	0.382	4.05	8.53	1.20	137	28.2	0.301	—	6.08	2.55	185
BQ12	0.207	1.520	5.39	0.055	12.90	85.3	4.79	504	26.2	27.9	58.9	1.30	0.418	6.19	9.65	1.91	146	33.4	0.398	88.6	6.04	3.14	189
BQ13	0.235	2.670	6.82	0.044	7.54	87.5	6.24	271	30.3	24.7	55.9	1.41	0.439	4.02	8.45	1.22	149	38.6	0.496	—	5.91	2.71	208
BQ14	0.313	2.040	5.52	0.042	11.80	76.7	4.95	417	26.1	23.2	51.5	1.16	0.510	3.81	8.15	1.06	130	30.9	0.432	—	5.44	2.49	207
Baqʿah Clays																							
BQ32	0.354	1.140	5.31	0.088	8.46	61.6	1.83	406	19.8	37.4	79.5	1.77	0.613	13.20	9.56	1.89	140.0	19.9	0.244	—	7.26	3.77	—
BQ33	0.114	0.776	2.37	0.051	34.10	35.0	1.81	151	9.2	13.9	29.4	0.68	0.236	2.35	4.03	0.79	54.4	19.5	0.207	41.5	2.87	1.18	—
BQ35	0.167	0.675	3.70	0.054	0.47	31.9	1.80	178	15.1	28.8	64.8	1.14	0.335	7.63	7.34	1.51	80.1	12.8	0.327	61.2	5.03	2.23	—
BQ36	0.099	1.040	1.67	0.021	34.40	28.2	1.53	157	6.4	11.4	21.3	0.47	0.163	1.68	3.31	0.49	78.3	5.1	0.522	78.5	2.22	0.92	—
BQ37	0.066	1.460	3.38	0.035	18.00	44.2	3.21	115	13.3	24.7	50.1	1.32	0.320	4.92	7.01	0.89	71.9	12.4	0.125	60.2	5.44	2.21	—

Because of prevailing westerlies and nearness to one of the strongest perennial springs in the valley, the wadi site would have been ideal for pottery manufacture. Together with BQ11-14 of LB I date, the clay samples also matched a large group of specimens from an Iron IA burial cave (McGovern 1981b). Thus, despite the evident cultural decline after *circa* 1200 B.C., potters appear to have used the same clay bed over at least a six hundred year period.

The considerable chemical divergence between the Chocolate-on-White/White Slip group (BQ8-10) and the local group (BQ11-14) strongly suggests a provenience outside the immediate Baqᶜah Valley-Wadi Zarqa region of Transjordan. Expansion of the Brookhaven ceramic data bank, especially in the areas of northern Jordan and coastal Syro-Palestine where the ware is well-attested, is needed in resolving the question of its origin.

Conclusions

The pilot study of the Baqᶜah Valley LBA pottery fabrics demonstrates the value of combining several mutually complementary techniques. The archaeological groupings appeared to make sense, but posed questions of provenience and technology that could not be answered at the macroscopic level. The petrographic examination, however, besides confirming the archaeological types and the high technological standard of the all the LBA wares, showed that the presumed local sherds were very likely from the Baqᶜah because of their affinity to local clays and sands/sandstones. Still, the non-characteristic mineralogy of all the sherds frustrated efforts to establish precise proveniences.

This shortcoming was bypassed with NAA, the accuracy of which is in fact improved for relatively pure wares. The Baqᶜah Mycenaean IIIB sherds were apparently not local imitations, nor even Cypriote products, but originated from central Mainland Greece itself. The Baqᶜah Base-Ring II sherds are more problematical, though a northeastern coastal Cypriote provenience seems most likely. Although the overland connection to the Baqᶜah is still untraced, a maritime trade route may have linked central Greece, northeast Cyprus, and the Levantine coast.

A very significant result was the chemical similarity of the presumed local group to a clay bed in the wadi below the associated settlement site. Later Iron IA pottery also matched the clay, so that a continuous tradition in the initial stage of pottery manufacture (collecting the clay) appears to be attested over a six hundred year period.

The provenience of the Chocolate-on-White and White Slip examples is still an enigma, and more analyses of clay and well-dated, well-provenienced pottery from a wider geographical area are required to elucidate this problem.

Finally, it should be stressed that conclusions are tentative. A much larger collection of Baqᶜah samples, now being studied, should provide a better statistical basis.

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