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CHAPTER 3

ANCIENT CERAMIC TECHNOLOGY AND STYLISTIC CHANGE: CONTRASTING STUDIES FROM SOUTHWEST AND SOUTHEAST ASIA

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1. INTRODUCTION

The form and decorative details of a pottery vessel are the end-products of a complex industrial sequence (Rye 1981). The process begins with the selection and preparation of raw materials (clay and temper) and continues through a variety of formation techniques (e.g., definition of the body of the vessel, trimming of the rim and base, and the attachment of handles and appliqués), surface finishing (such as smoothing, slipping, or painting), and firing.

A standard typological analysis of an archaeological corpus assumes that the potter's primary goal was to produce a particular form, which had been established by conscious and unconscious cultural traditions. From this perspective, pottery served definite functions within a society, whether as utilitarian or prestige items, and changes in style are seen as reflecting changes in the society as it interacted with its environment and other societies.

The emergence and subsequent development of a stylistic tradition, however, is conditioned by and can be very much dependent on underlying technological traditions. In general, any stage in the industrial sequence may impact on another stage in the same sequence. For example, the unavailability of high-quality raw materials or limited expertise in their preparation might inhibit the development of a wheel-throwing tradition. Form can also be a function of the decoration that is envisioned, whether expanding the shoulder space on a vessel for more elaborate painting or making a more open form that can be more efficiently slipped and painted.

A further consequence of an appreciation for the significance of the underlying technology is that the same finished form or decoration may have been achieved in quite different ways, even within the same culture. Thus, although two vessel types might appear to be identical, they can in fact be distinguished by what might be described as a sub-macroscopic typological distinction. Often, such evidence of the ceramic industry and the change or perseverance of its traditions with time can be more valuable than visible criteria in elucidating the socio-economic development and foreign contacts of a society, since the entire industrial sequence, not just the finished product, represents the supply side of the market or demand for the pottery. For example, high-fired wares attest to pyrotechnological expertise, and imported pigments are evidence of foreign trade.

The study of pottery from two sites, one in southwest Asia (the Baq'ah Valley of Jordan) and the other in southeast Asia (Ban Chiang, Thailand), is illustrative of the value of

detailed technological analysis. The temporal span of the Jordanian pottery was more limited (about 500 years) than that of the Thai assemblages (over 3000 years). The Jordanian study, however, was focussed on a transitional period of rapid cultural and technological change, the Late Bronze Age (LBA)-early Iron Age (ca. 1550-1050 B.C.). The time span of the Thai study, which is very long in comparison to most ceramic studies, demonstrated that a highly conservative tradition had existed in the Ban Chiang area since about 3600 B.C.

2. ANALYTICAL APPROACH

In most cases, only finished pottery is available for study, which places a premium on complementary analytical techniques that can provide various kinds of data from which inferences can be drawn about the production stages. If the ancient pottery manufacturing installations can be found or if the original raw materials are known, then the industrial sequence can be much more convincingly established, in conjunction with replicative experiments.

In the Museum Applied Science Center for Archaeology (MASCA), a routine procedure, represented by a flow chart (Fig. 3.1), has been developed for analyzing a corpus of pottery. The initial problem, especially for a group of finished pottery vessels, is to select a representative collection of specimens from a much larger corpus. The crucial factors at this stage will be primarily macroscopic criteria (vessel form, surface decoration, ware color, etc.), bearing some relation to the manufacturing process, and the results of previous investigations. Low-power microscopic observation (using a stereozoom scope with fiber-optic lighting, up to $\times 180$) was an important adjunct in preliminarily defining wares, and formation and finishing methods. Specific ceramic questions are also posed at this level of analysis. The pilot study may resolve some of these questions; depending upon the analytical results, other questions may have to be recast or the sample size enlarged (which might be indicated by feedback arrows on the flow chart). As technological interpretations are progressively refined, cultural inferences are correspondingly strengthened.

It is most convenient initially to separate the xeroradiographic study of fabrication methods from the petrographic analysis. Although it is desirable to study many of the same samples by a combination of analytical techniques, additional larger specimens from

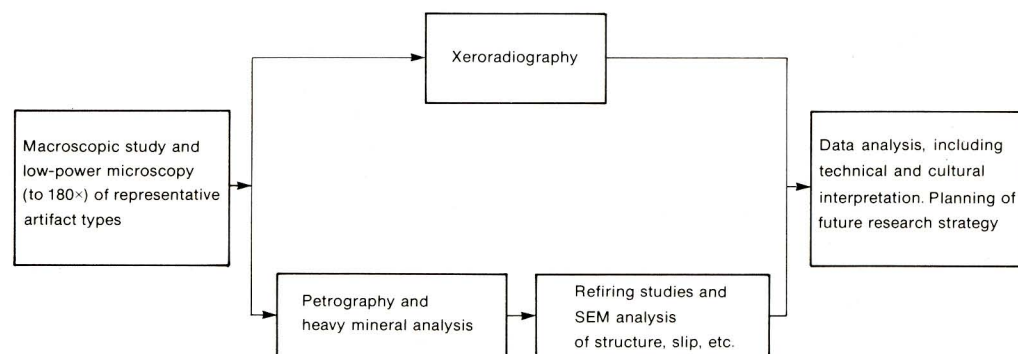


Fig. 3.1 Flow Diagram of MASCA Archaeoceramic Program.

specific parts of a vessel, in particular the rim and base where there was the inevitable problem of what to do with excess or insufficient clay, often need to be X-rayed. The interpretation of inclusions and voids on a radiographic image can also be ambiguous, e.g., the lighter mineral inclusions such as calcite and quartz are essentially transparent to the X-ray beam (non-radiopaque) and indistinguishable from voids (except in the case of more angular shapes).

The petrographic analysis bears most directly upon the refiring and scanning electron microscopic (SEM) studies of the original firing temperature range, structural and chemical ware properties, and surface decorations (slips, paints, etc.) of the ancient pottery. For example, specific mineralogical changes, such as the transformation of green to brown hornblende at ca. 750°C (Kozu *et al.* 1927, Barnes 1930), provides evidence of the original firing temperature, and ware types are partly defined by their mineral suites. On this basis, a group of samples, representative of a ware type, was refired over a specific temperature range to delimit the original firing range for that ware type. The assumption that fabrics containing similar inclusions were made from the same clay was tested for the Jordanian corpus by neutron activation analysis (NAA), but such an assumption, even without supporting evidence, is reasonable. Slips and other surface layers are best characterized structurally and chemically by SEM; their presence/absence, however, can often be established under low-power magnification by colour and structural differences as contrasted with the body ware.

Presently, the MASCA ceramic program does not routinely include neutron activation analysis and X-ray diffraction of ancient pottery, although these techniques provide unique sets of data (as discussed later). It might also be argued that an ethnographic study of modern potters in the region under study is an essential component in reconstructing the ancient ceramic technology and its cultural import.

3. ANALYTICAL TECHNIQUES

Xeroradiography employs standard X-ray equipment, but the resulting paper image has higher contrast and edge enhancement than an X-ray negative (Glanzman 1983, Glanzman and Fleming 1986, 164-77). For pottery studies, the contrast between air voids (e.g., those between coil surfaces, and those where organic matter has burned out) and the clay matrix will be highlighted. Voids resulting from constructional methods, however, can be obscured and even obliterated by the subsequent formation and surface finishing of the vessel. By using "thick-sections," tiles cut perpendicularly to the vessel's surface and at least as wide as the average thickness of the vessel sidewall, X-ray beams can more readily be directed along the interface planes of clay members, thus revealing the seams between joined coils and slabs. The thick-section and a surface view of the piece it was cut from were X-rayed together, providing cross-sectional and surface images on the same xeroradiograph. A non-deformational diamond saw was used in cutting the thick-sections, as well as in preparing the tiles that were refired and studied by SEM.

The petrographic analysis had two components: (1) a standard microscopic examination of thin-sections to identify the predominant inclusions in each fabric and their size distribution, general shapes, and volumetric contribution by point counting; and (2) an inclusion analysis of the heavy minerals present in disaggregated 25 mg. samples.

The ancient firing temperature range for each ware type was determined as follows. The

original degree of vitrification of clay particles in a vessel was compared with that of refired tiles cut from that vessel and others of the same ware type; in the case of the Jordanian corpus, where the ancient clay source was known and could be sampled, briquettes were made up from that clay. Each briquette or tile was then fired to a specific temperature (typically, 500, 600, 700, 800, 900, or 1000°C). The tiles were heated with a servo-controlled muffle furnace for eight hours in an oxidizing atmosphere (Chazan and McGovern 1984). According to terminological distinctions in the literature (Tite *et al.* 1982), an initial vitrification structure (IV) shows minimal fusion between clay particles whereas an extensive vitrification structure (V) will have large coalesced areas. The color changes of the wares and surface layers upon refiring in an oxidizing environment can also be of value in qualitatively assessing the original temperatures and environments of the firings. Color readings, which were taken under subdued natural lighting, were denoted by their Munsell equivalents. The ware readings were taken from just below the exterior surface.

The presence/absence of slips and other surface layers was established with an SEM, at magnifications typically in the $\times 300$ to $\times 1000$ range (Chazan and McGovern 1984). A coupled energy dispersive system on the SEM enabled the chemical composition of the fabric and any surface layer to be semi-quantitatively analyzed.

Samples for neutron activation analysis (NAA) were obtained by drilling out interior fabric from a cross-section with a tungsten-carbide bit or, more frequently, by breaking off a small fragment and pulverizing the material in an agate mortar. In either case, the relevant surfaces (cross-section or interior and exterior surfaces) were removed to a depth of about a millimeter with an alumina burr; this reduced the possibility of surface contamination. Samples weighing 200 mg. were considered to be representative of the overall fabric, especially since the primary mineral inclusion (quartz) generally acts as a diluent for the elements measured by NAA (Harbottle 1976). Irradiation and data processing procedures for the Baq'ah analyses carried out at Brookhaven National Laboratory are described in detail in several references (Abascal *et al.* 1974, Weigand *et al.* 1977).

4. LATE BRONZE AND EARLY IRON AGE JORDANIAN POTTERY: AN INDUSTRY IN TRANSITION

The Baq'ah Valley is a very fertile depression on the central Tranjordanian plateau, located 15 to 20 kms. northwest of Amman and at about 625 m. above sea level. Intensive archaeological and geophysical surveying, which was followed by selective test soundings, have shown that the Baq'ah supported an urban population in the LBA, which shared in the international trading network of the period (McGovern 1986, McGovern 1982). Social and economic dislocations, perhaps in combination with environmental deterioration, toward the end of the Late Bronze Age, led to a more dispersed settlement pattern of villages, with a distinctly lower standard of living and reduced foreign contacts, in the Iron IA period (ca. 1200–1050 B.C.).

This seemingly dramatic cultural shift is reflected in the pottery, and indeed has been cited in support of an external invasion of new peoples (such as the Philistines, Ammonites, and Israelites), who would have brought new styles and technologies with them. Thus, a major proponent of this view, W.F. Albright (1932: 58–61), argued that the so-called collared-rim storage jar (which has a ridge running around its shoulder) was a type fossil of the Israelites. Other types, such as the one-handed cooking pot and a button-based juglet

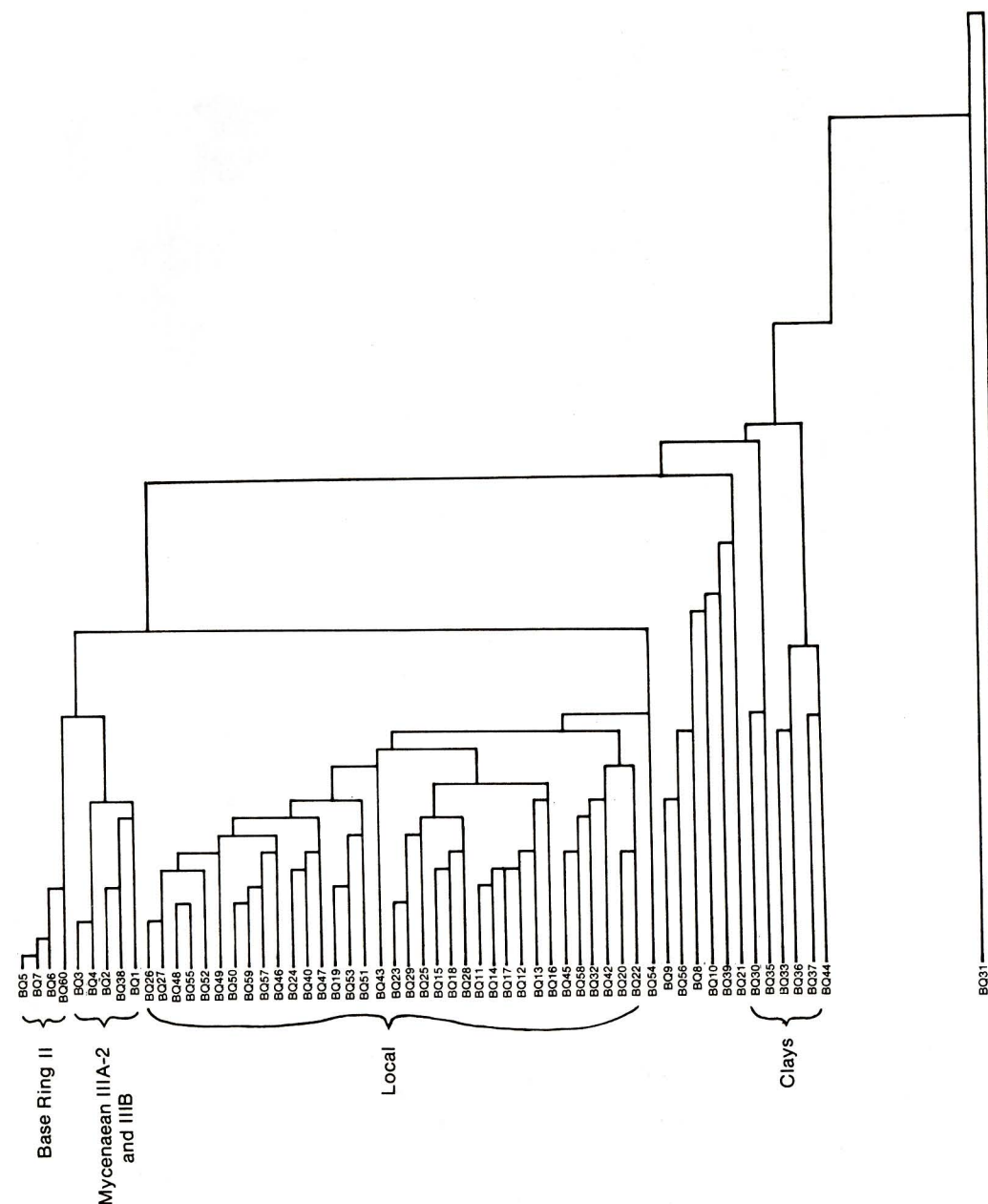


Fig. 3.2 Neutron activation analysis dendrogram of Jordanian pottery. The local group includes specimens of Late Bronze and early Iron age date.

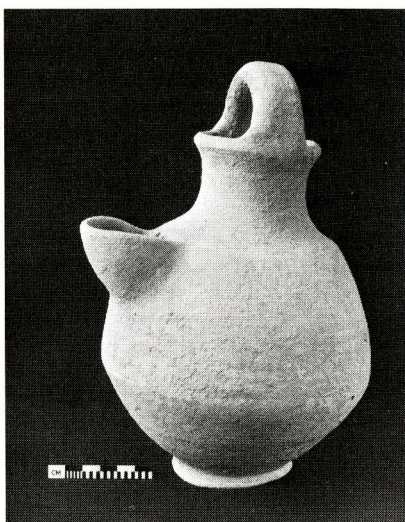


Fig. 3.3 So-called beer-strainer (field no. A4.4) with Philistine affiliations from the Baq'ah Valley (Jordan), dating to Iron IA. (Photograph: N. Hartmann.)

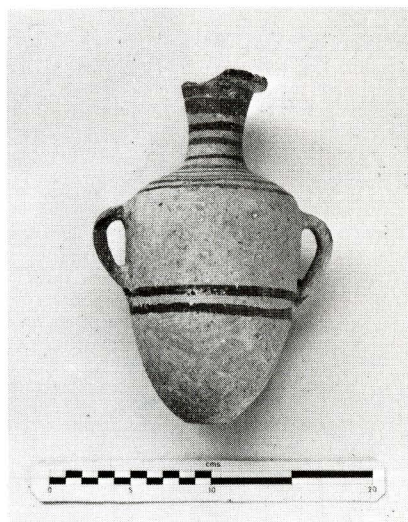


Fig. 3.4 LB I amphoriskos (field no. A2.5), with red and black horizontal bands, from the Baq'ah Valley, Jordan. (Photograph: P. McGovern.)

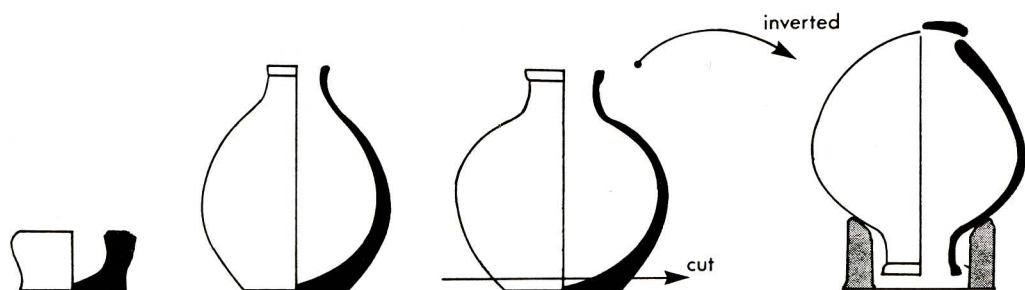


Fig. 3.5 Construction drawing for the formation of an LB I Jordanian storage jar. It was wheel-thrown in the upright mode. After the base was cut through and the vessel inverted, the hole was sealed by an externally applied slab.

with an elongated neck, also appeared for the first time in the early Iron Age. An apparent decline in ceramic standards is also cited in support of this thesis, and Albright went so far as to describe Iron I pottery as some of the worst ever produced in Palestine.

Apart from Franken and Kalsbeek's study (1969) of Iron Age pottery from Tell Deir 'Alla in the Jordan Valley, very little is known about the pottery technology of this period, so that the invasion hypothesis as applied to or derived from the ceramic evidence has never been properly tested. A study of the Baq'ah corpus, covering the entire LBA and early Iron Age (about 500 years), thus constituted the first critical appraisal of the pottery evidence for this transitional period and its bearing on cultural and historical interpretations. The primary assemblages were an overlapping temporal sequence of three burial caves (dating to LB I [ca. 1550–1400 B.C.], LB II [ca. 1400–1200 B.C.], and Iron IA [ca. 1200–1050 B.C.]), and associated LB II deposits at the nearby LB-early Iron settlement site.

A pilot NAA and petrographic study (McGovern *et al.* 1982) of fourteen LB specimens demonstrated that pottery, which was presumed to have made locally on the basis of stylistic criteria (primarily LB I types), derived from a clay deposit in a wadi (Umm ad-Danair), directly below the settlement site and in the vicinity of one of the strongest perennial springs in the area. In addition to the clay and water, other requisite materials for pottery manufacture (e.g., friable limestone and sandstone for temper) were located close by, making this an ideal location for a workshop.

With the recovery of LB II and Iron IA tomb groups and the LB II occupational material, an expanded study could be carried out. The number of analyzed LB examples was increased for greater statistical reliability, and the MASCA ceramic program now included xeroradiographic, refiring, and SEM studies. Altogether 47 Baq'ah local specimens (11 LB I, 21 LB II, and 15 Iron IA) were studied by NAA, petrography, and SEM (McGovern *et al.* 1986, 178–93). The formation methods of 134 examples were determined by xeroradiography (Glanzman 1983, Glanzman and Fleming 1986, 164–77).

One of the most significant NAA results was that all the presumed local pottery, including the LB I pottery of the pilot study and the LB II and Iron IA pottery of the subsequent study clustered together (Fig. 3.2), and of all the clays tested only the wadi clay (BQ32 in Fig. 3.2) was in the same grouping. Even newly introduced types of the Iron Age and decorations with foreign affiliations (Fig. 3.3) were produced from this clay. Therefore, over the 500 year period and despite cultural changes, one aspect of the pottery industry remained constant – the clay source.

Although the same clay source was exploited, the other analytical results revealed a gradual transformation in the pottery industry. The LB I vessels, both large and small forms, including bowls, lamps, kraters, jugs, and storage jars (Fig. 3.4), had been thrown on a wheel. The LB I jugs/jars and medium-sized bowls shared another feature: a hole had been left in their bases when they were cut off the platform in the upright mode (Fig. 3.5). The hole was subsequently filled with a plug and covered with an external patch of clay. By LB II, however, most of the forms, apart from small bowls and lamps which were thrown "off the hump," were built up by coils (Fig. 3.6). The bases on the jugs, jars, and larger bowls were now closed by pulling up and "choking off" the clay in the upside-down mode. Interior and exterior patching was usually required to strengthen the bases. A clear-cut demarcation, however, does not exist between the periods; coil-made vessels and upside-down closures, although infrequent, are attested in LB I, and some wheel-made vessels with basal plugs occur in the LB II corpus. In Iron IA, coil-building became the exclusive

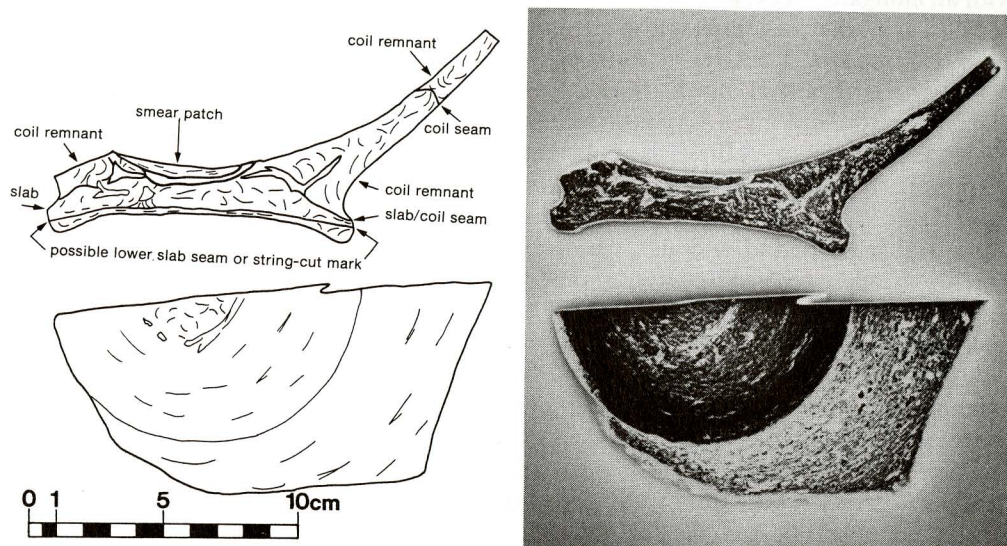


Fig. 3.6 Xeroradiograph and drawing of LB II large bowl (field no. B3.261). The vessel was coil-built in the upright mode upon a slab base. The coil terminus at the juncture with the slab retains the typical circular air voids from coil remnants, whereas the slab base has irregular or roughly parallel-to-surface void orientations. An interior smear patch, of the same fabric as the rest of the vessel, has parallel-to-surface void orientations. In the surface image, this patched area stands out with a highly irregular orientation pattern. The patch was poorly applied, trapping a large air pocket. Measurement conditions: 60 kV, 150 mas, 1.00 sec., 1.02 m. focal distance.

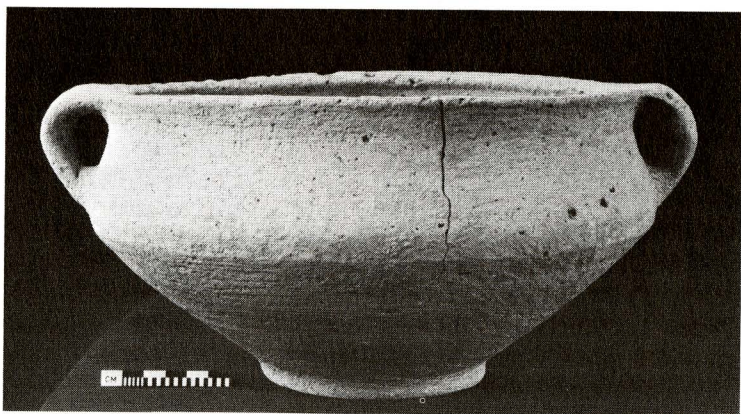


Fig. 3.7 Iron Age krater (field no. A4.31) from the Baq'ah Valley, Jordan. (Photograph: N. Hartmann.)

method for making the larger forms; a tournette, however, continued to be used to manufacture small bowls and lamps. Indeed, the very well-proportioned, thin-walled forms of the early Iron Age appear to have been produced in a more exacting fashion than their LB predecessors (Fig. 3.7). Bases were also better trimmed, which in turn reduced the number of cracks and the necessity of patching.

Contemporaneous with the gradual change-over from wheel-throwing to coil-building, a developmental sequence in the mineralogy of the local assemblages can also be followed (Fig. 3.8). Although the mineralogy of the local pottery was extremely non-descript, as is characteristic of sedimentary deposits, a general trend in the greater volumetric percentages of quartz and calcite from period to period was observed. Most of the local specimens belonged to one of two categories: (1) those containing quartz inclusions alone, and (2) those containing both calcite and quartz inclusions. The sizes of the major constituents were normally distributed in a unimodal fashion, with an average diameter of 0.29 mm. for all the local pottery. A detailed examination of the voids in the LB pottery was required to detect reaction rims and remnant particles in accurately assessing the amount of calcite. Thus, for examples with only quartz inclusions, the following percentages were recorded: 2.75% (LB I), 4.73% (LB II), and 6.05% (Iron IA). For specimens in which quartz and calcite were found together, the percentage of each aplastic declined in LB II, and then rose above the LB I percentages in Iron IA: 2.63% quartz, 2.50% calcite (LB I); 1.72% quartz, 2.41% calcite (LB II); and 3.50% quartz, 3.25% calcite (Iron IA).

The clay from the wadi source, besides having a similar suite of accessory minerals as that of the ancient pottery, contained variable amounts of quartz (1–70%) and calcite (up to 5%). The well-rounded shapes of the quartz and calcite grains in the pottery was

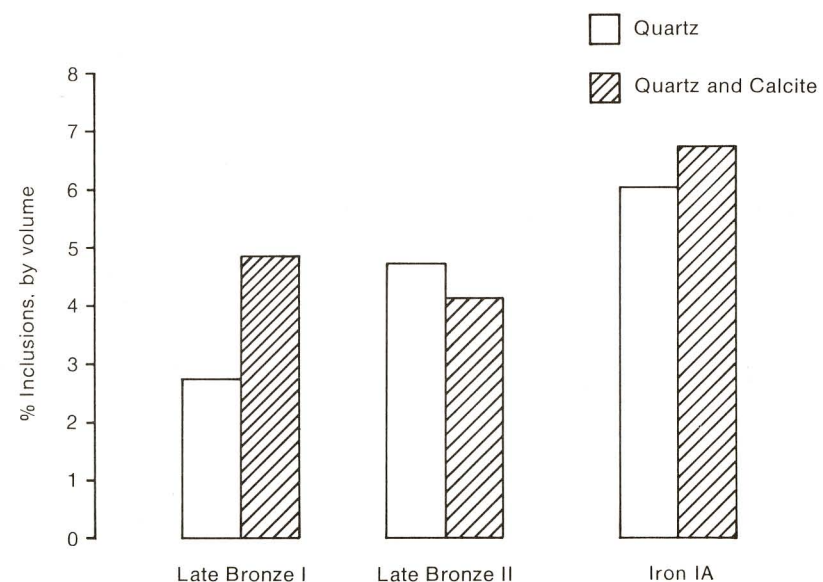


Fig. 3.8 Histogram of primary mineralogical inclusions in Late Bronze and early Iron Jordanian pottery.

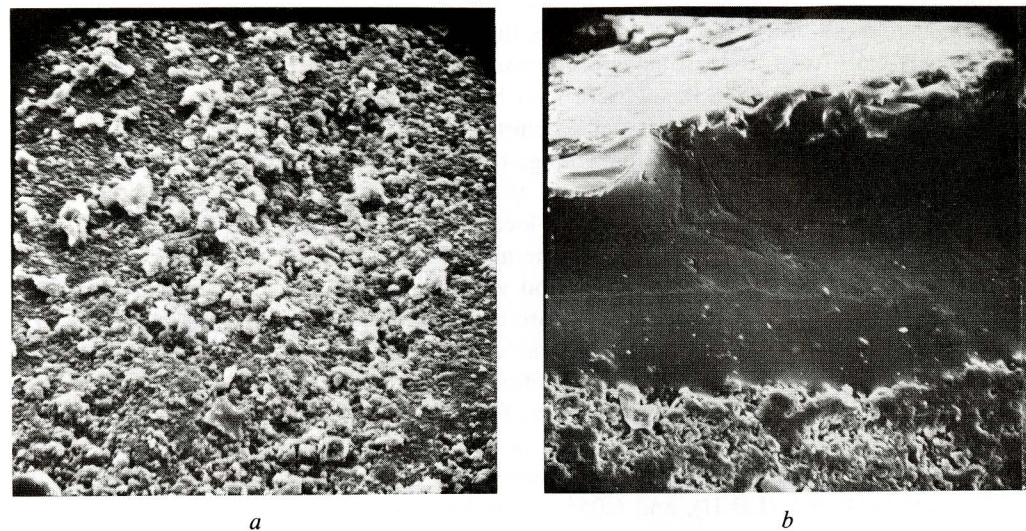


Fig. 3.9 (a) SEM micrograph at $\times 950$ of interior fabric of Jordanian Iron IA lamp (field no. A4.29), and (b) SEM micrograph at $\times 360$ of slip on LB II jug (field no. B3.86). Note the extensively vitrified structure of the slip on the latter, which is as much as 200 microns thick in places, as compared with the underlying ware with intermediate vitrification. (Photographs: a) P. McGovern; b) M. Chazan.)

comparable to those in the clay, as well as to those of friable limestone and sandstone from the region. It is possible that the latter or a wadi sand was added back to the clay as temper, but the unimodal distributions of grain sizes make it more probable that the inclusions come from the clay. The latter might either have been differentially levigated or selected areas of the deposit, with differing amounts of quartz and calcite, worked out over time.

The refiring experiments, using briquettes made from the wadi clay, which were fired at 50 and 100°C increments over the temperature range from 400 to 1050°C, demonstrated that the original firing temperature of the calcareous ware decreased from 700–850°C in the Late Bronze Age to 500–700°C in Iron IA (Fig. 3.9). Greater precision in estimating the original firing temperatures is dependent on a fuller knowledge of several interacting variables – the highest temperature attained, the period of time at various temperatures, and the relative exposure of the pottery to oxidizing and reducing conditions. This conclusion was also borne out by the predominant colors of exterior subsurface of the LB pottery as compared with that of the Iron IA pottery: the typical Iron IA coloration (5YR 4/6, yellowish red) developed between 500 and 600°C; the colors lightened somewhat between 650 and 750°C, and then changed to redder hues above 750°C, which were comparable to the color range of the LB wares (2.5YR 6/6 to 7.5YR 8/6, light red to pink). Less consistent firing was already apparent in the LB II corpus from the greater frequency of thick cores (unburnt organics) and oxidation/reduction spots on surfaces.

A notable stylistic difference between the LB and early Iron pottery is that the latter was seldom decorated. Slips were infrequently used, and a red painted decoration occurred only on one of 70 vessels (Fig. 3.3). Although rare, SEM examination revealed that the

slips/paints were structurally and chemically similar to the LB surface applications (i.e., they were non-calcareous, vitreous, and the red was due to an elevated iron content).

Despite the apparent stylistic differences between LB and Iron IA central Transjordanian pottery, technological continuity between the LB II and Iron IA assemblages (as opposed to the LB I group) is more evident than change. To be sure, by the early Iron Age, a very obvious shift in techniques and materials had taken place in the pottery industry, but the initial steps in this process had already begun in LB II. Similarly, changes in other sectors of the Transjordanian society, such as the displacement of the urban system by a dispersed village settlement pattern and the beginnings of iron/steel production, can be traced back into the LBA (McGovern 1986).

The pottery industry exemplifies this transformation. The change-over to more heavily tempered wares and coil-building had occurred in LB II. The Iron IA potters, presumably working in greater isolation and at a lower standard of living than their predecessors, appear to have made the best of their material limitations and in fact refined their techniques, including the production of forms that were better adapted to coil-building and low temperature firings.

The gradual transformation in the ceramic industry in central Transjordan fits with a relatively peaceful, indigenous socio-economic transformation on the central Transjordanian plateau in the LB and early Iron Ages (McGovern 1986). The invasion of the Sea Peoples along the coast, continued Egyptian presence along the main trade routes, and the encroachments of other peoples had serious economic and social repercussions on Transjordan in the period after 1200 B.C. Central markets for the collection and redistribution of exports (principally agricultural produce and livestock) and imports (luxury goods, pigments, tin, etc.), together with the stratified society (political rulers, priests, merchants, craftsmen, peasants, etc.) that supported the urban system, would have been seriously undermined. The eventual collapse of this system would have had a major impact on the pottery industry, and, on the basis of presently available evidence, it accentuated the transformation of the industry along lines that had already been set. Changes had begun to occur in LB II, in response to a changing cultural and environmental context, and the primary factors contributing to technological and stylistic change must be sought in this period.

One plausible reconstruction might be that the mass production of pottery in LB II (as evidenced by a dramatic increase in the number of vessels per burial) resulted in a general decline in potting standards. Consequently, clay may have been less well levigated, a development that would have been exacerbated by a decline in rainfall toward the end of the Late Bronze Age, as suggested by pollen profiles (McGovern *et al.* 1986, 178–93). Clay with more inclusions can be more efficiently formed by coil-building than by wheel-throwing, and the water requirements are less for coil-building.

Under such circumstances, some changes in types and wholly new forms would be anticipated with the introduction of a different fabrication method (coil-building). Also, if the clay contained more calcite, lower firing temperatures would be desirable to prevent it from burning out and thus weakening the fabric. Finally, the relative lack of slipping in Iron IA may be more a result of decreased quantities of fine clay fractions than an intentional stylistic change.

The technological factors contributing to stylistic change need to be considered alongside other cultural factors. The Iron IA period of central Transjordan is properly described as a

"Dark Age," and new pottery styles and even the predilection for a relatively new fabrication technique could have represented visible symbols of the a new order, which in other contexts has been described as a "revolution" (Renfrew 1978).

The complex interaction between the ceramic industry, the cultural milieu, and the environmental setting on the LB-early Iron central Transjordanian plateau has been only partly elucidated by archaeological investigation. Whatever causal factors, however, finally emerge as most important in understanding the transformation in the ceramic industry (one avenue of future research is the investigation of ancient pottery working installations), the main trends, the timing of technological changes, and the probable impact of the latter on the pottery styles are clear.

The general cultural and historical implications of these developments in the pottery industry of central Transjordan are significant. At least in one area of Palestine, the apparent stylistic differences of Iron IA pottery is better explained by endogenous circumstances rather than external (diffusionist) factors, such as the invasion or peaceful infiltration of a new people bringing new pottery styles with them (best illustrated by the arrival of the Philistines, a Sea People, with Aegean-inspired ceramics, ca. 1150 B.C. in the southwestern coastal area of Palestine). The LB I pottery repertoire of central Transjordan may be considerably different from that of Iron IA, but they are tied together by a continuous industrial tradition, with the major technological changes of LB II having been appropriated by the early Iron potters and then reflected in their pottery styles.

5. BAN CHIANG POTTERY: THE PERSISTENCE OF TRADITION

Ban Chiang lies on Thailand's Khorat Plateau, about 500 kms. northeast of Bangkok and about 50 kms. south of the Mekong River, close to the Thai-Laotian border. Although best known as a site of early bronze production in southeast Asia, its ceramic sequence perhaps best typifies the site's cultural development over three millennia (White 1982). The pottery studied is exclusively from funerary features, which have been chronologically ordered on the basis of stratigraphy and radiocarbon dates as follows: Early Period (ca. 3600–1000 B.C.), Middle Period (ca. 900–400 B.C.), and Late Period (ca. 300 B.C. – A.D. 200).

A pilot study of a select sample of Ban Chiang pottery was carried out to resolve specific analytical questions and as a basis for future investigations (McGovern *et al.* 1985). For example, were the firing temperatures sufficiently high to suggest interaction in the metal and ceramic pyrotechnologies during any period? Were surface color variations a result of firing conditions, raw materials, or surface applications? What fabrication techniques were employed to produce the various forms? With such questions in view, twelve vessels from secure funerary contexts of the Early, Middle, and Late Periods were sampled for petrographic, refiring, and SEM studies. Three additional Early Period and three modern vessels were included in the xeroradiographic study. Most of these vessels represented common, diagnostic types at the site, and hence were probably locally made.

In contrast to the LB-early Iron pottery sequence in Jordan, the styles and underlying technology of the Ban Chiang ceramics showed remarkable continuity. The most common form, a globular vessel (Fig. 3.10), was produced during the Early Period, and continued to be made in the Middle Period, Late Period, and up to the present day. The intricate curvilinear and geometric designs, which were achieved by painting and/or impressing in the three archaeological periods, are still used today by northeast Thai potters. The details

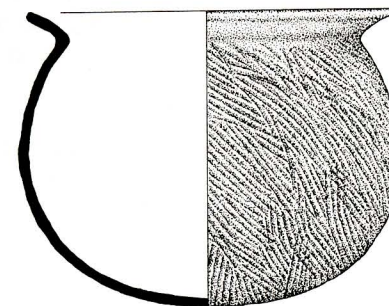


Fig. 3.10 Ban Chiang globular jar (field no. BCES B.56 C), dating to the Early Period (Phase II). (Drawing: K. Galligan $\times \frac{1}{4}$)

and combinations of decorations and vessel forms certainly differ from period to period, and a very high aesthetic level had already been set in the Early Period. Nevertheless, the outstanding stylistic differences that occur from period to period – such as the preference for elaborate painted decoration in the Late Period or sharply carinated forms in the Middle Period – are part of a long and very stable tradition.

The ceramic technology reflects the continuous stylistic tradition. The primary methods of fabrication in the Early Period were paddle-and-anvil formation of either coils or a lump built up on a slab base (Glanzman and Fleming 1986), and modern potters can be observed using the paddle-and-anvil method to shape a single lump of clay.

Comparison of the degree of vitrification of the ancient pottery (IV) with the refired tiles of the same specimens revealed that the pottery of the three ancient periods had been uniformly low-fired (500–700°C), which was further supported by the presence of low-temperature brown mica or green hornblende. The prevalence of exterior oxidation and reduction spots and thick cores indicated that the firing process in all periods was probably poorly controlled and of short duration. In view of the low firing temperature range, it is probable that the pottery was fired in the open by piling the fuel up and around the vessels, as is still the practice today. Since refiring to 900°C caused surface cracking of the ancient pottery, higher temperature firings might have been purposely avoided.

The mineralogy of Ban Chiang groups is somewhat more variable (Fig. 3.11). The main inclusions (grog, quartz, and plant material), which had been intentionally added as temper, were used in various combinations in all periods. However, Early Period (Phase II) pottery was tempered primarily with grog and quartz, along with varying amounts of rice plant material (Yen 1982). The latter was the pre-eminent tempering material in the Middle Period, although still accompanied by quartz (amounts less than 5%, however, may have entered via the clay) and sometimes grog. In the Late Period, grog was preferred, plant material was at very low levels (maximum of 0.1%), and the quartz content ranged between 1 and 13%. In addition, all the wares of each period contained sponge spicules and fresh-water diatoms.

The accessory mineral assemblages of each period differed in several respects: the Middle

Period ceramics were generally depleted in heavy minerals, and only the Early Period examples contained brown mica and monazite and the Late Period pottery, hornblende. In the Ban Chiang area today, the preferred temper is a grog that is prepared from ground-up fired-clay balls, which are rice-tempered (Vincent 1984). The grog of antiquity was quartz-tempered.

The red paints, which were documented for all the periods, were quite comparable structurally and chemically in the Middle and Late Period (Early Period examples have not yet been examined). An overall body slip of the same type occurred only in the Late Period. The surface layer was quite thin (10–50 microns thick) and vitreous. The iron level was elevated and the calcium level of the essentially non-calcareous ware (1–2% CaO) usually slightly depressed.

An exceptional slip/paint composition occurred on an unusual carinated form of the Middle Period with an intense white ware color (Fig. 3.12). The red paint on these vessels had much higher iron contents (as much as 24% ferric oxide) than the paints/slips of the Late Period, and the calcium amount was somewhat increased over that of the ware. According to preliminary NAA results, the clay is closer to a kaolinite (lower levels of aluminum, iron, magnesium, and titanium) rather than a smectite, which was generally used in making the Ban Chiang pottery of all periods. Metakaolinite ($\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$) forms from kaolinite when it is heated above 550°C (Heimann and Franklin 1979), and is most likely responsible for the vessels' white coloration (Noll *et al.* 1975).

Based on these analytical results of over three thousand years of Ban Chiang ceramics, the pottery industry of the area appears to have been highly conservative. Already in the earliest period available for study, a variety of fabrication techniques had been developed to produce a range of forms that are made in much the same way (i.e., by paddle-and-anvil)

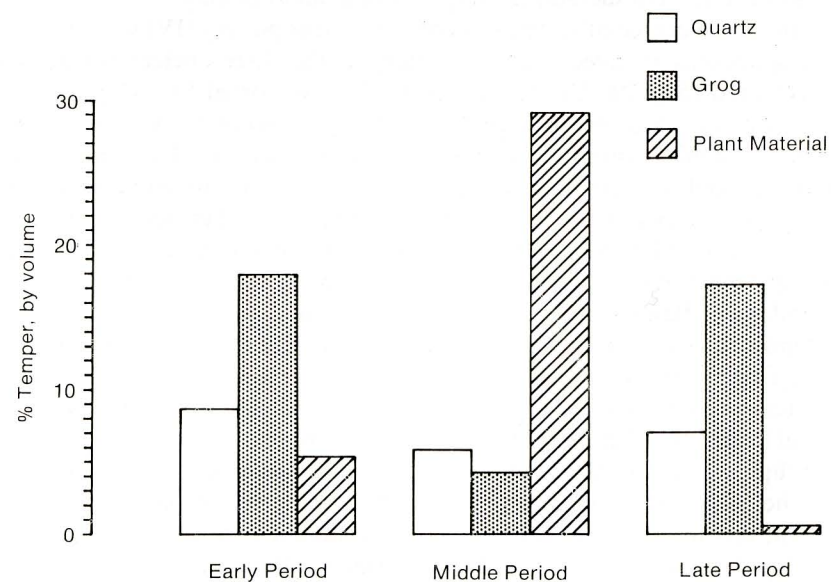


Fig. 3.11 Histogram of temper contents of prehistoric Thai pottery.



Fig. 3.12 Ban Chiang white, carinated vessel (field no. BCES B.40 G), dating to the Middle Period. (Drawing: K. Galligan; $\times \frac{1}{4}$)

in the area today. The methods and materials for the vibrant geometric decorations of the Early Period have an equally long history. The various tempering materials (quartz, grog, and plant remains) were all used in the Early Period II phase and in later periods. Finally, the firing of the vessels was at consistently low temperatures and carried out under both oxidizing and reducing conditions in all periods.

The postulate of a stable social and environment context would seem to be implied by the perseverance of traditions at every stage in the production process, including a range of techniques, which had already been developed by the earliest period available for study, that were particularly well-suited to the materials at hand. The cultural development and environmental setting of the prehistoric Khorat Plateau, however, is still poorly understood, and the implications of the small body of ceramic data must remain tentative at best.

Thus, although the conservatism of the pottery industry is most noteworthy, the variations from period to period point to some technological change. For example, the

differences in heavy minerals would imply that different clay sources were being exploited in each period (the presence of fresh-water diatoms and sponge spicules in the ancient pottery suggests that lake deposits, which are very numerous on the plateau and a modern source of clay, were exploited). The relative paucity of heavy minerals and quartz in the Middle Period ceramics, in conjunction with a kaolinitic clay, further suggests that the clay was better levigated or that purer clay deposits were being exploited. Middle Period pottery also stands apart from the other two groups in its consistently high levels of plant material as temper, which was most often used alone. The fabrics of the two white, carinated vessels, being tempered with a combination of quartz, grog, and organics, are very different from those of the other MP vessels, and perhaps provide evidence for a continuous technological tradition between the Early Period II phase and the Middle Period.

While some parameters of the production of Ban Chiang pottery (e.g., the firing temperature range) were well defined in this study, more detailed analysis and a larger sample is desirable in resolving a number of issues. NAA analysis of more than sixty vessels and several modern clays from the Ban Chiang area has been initiated in collaboration with R.V.G. Hancock at the University of Toronto's SLOWPOKE Reactor facility), to characterize the raw materials of the ancient pottery tradition more closely. By extension of the petrographic studies, it should be possible to document more precisely the change in tempering that must have occurred toward the end of Early Period or the beginning of Middle Period. The statistical base for the radiographic study also needs to be expanded to determine the extent and timing of substantive developments in fabrication techniques.

Pending a more detailed study, several preliminary observations may be made about the relationship of the Ban Chiang pottery industry to that of other northeastern Thai sites. Even though there are some similarities in vessel forms, the fabrics of the nearby site of Ban Na Di (Vincent 1984) are clearly different from the wares included in this study. This is true even for the examples that were considered to have been possibly imported from Ban Chiang. Much farther to the southwest, Non Nok Tha pottery, which is contemporary with Ban Chiang's Middle Period, is almost exclusively tempered with quartz (Bayard 1977). Higher firing temperatures (800–1000°C), probably using a kiln, were also attested for pottery from Non Nok Tha of Early Period and Middle Period date (Meacham and Solheim 1979).

The ceramic technological evidence from the Ban Chiang pilot study supports the hypothesis that a number of relatively isolated centres of pottery manufacture, of which Ban Chiang was one, probably existed on the Khorat Plateau from the third to the first millennium B.C. The study of material earlier than the Early Period pottery might help to elucidate the common origins, if any, of the various industries, as well as to explain the emergence of such resilient and persistent technological and stylistic traditions.

6. CONCLUSIONS

Stylistic and typological analysis of a pottery corpus has been a primary concern of archaeological systematics, since pottery is often the most abundant inorganic evidence of an ancient culture. The relationship that style bears to the culture as a whole or specific entities within it, as well as the extent to which it incorporates conscious or subconscious factors, has been widely debated (Flannery 1976, 251–54).

If the cultural basis of pottery styles is not well understood, then accounting for change in

pottery styles is beleaguered by even more problems. Not the least of these problems is the small archaeological data base that is available for a culture, and archaeological reconstructions are probably best viewed as working hypotheses. Where contemporaneous historical or pictorial evidence exists, this can often provide an expanded perspective on the social and economic import of specific pottery styles or design elements (Lucas 1962, Holthoer 1977), but a proper assessment of this evidence and its limitations requires its own canons of analysis and judgment.

The contrasting case studies of the two prehistoric pottery corpora presented here (LB-early Iron central Transjordan and Early-Late Period Ban Chiang, Thailand) serve to highlight the importance of a crucial element in the emergence and subsequent development of any ceramic style, viz., the underlying technology. This aspect of pottery study has not often been accorded the same detailed treatment that has been given to typological, art historical, and other types of analyses (e.g., locational and ethnoarchaeological). And yet, the materials and methods of pottery manufacture set specific boundary conditions as to which pottery styles are possible and most suitable for production.

The Jordanian and Thai studies are intended to be suggestive rather than definitive of how changes in pottery styles can occur. Thus, changes in the underlying technology of the Baq'ah pottery (more heavily tempered wares leading to more coil-building and lower firing temperatures) would appear to have directly mediated the observed changes in pottery styles. The Ban Chiang stylistic uniformity, on the other hand, is matched by a conservatism in the ceramic technology.

Other possible cultural and environmental factors (including those that impacted directly upon the ceramic industry) are not ignored in these studies, but the immediate bearing of technological factors in two very different cultural and environmental settings demonstrates the potential value of this approach in other contexts.

The studies also relate to a subsidiary issue – the use of ethnographic analogies in archaeological interpretation. Where there has been a constancy of tradition (Ban Chiang), then ethnographic parallels are especially apposite. Where cultural change has been the rule (Jordan), modern pottery workshops are apt to be quite different from those of antiquity.

As final note, two case studies can hardly encompass the rich fabric of the "ecology" and history of ceramics, and each instance of stylistic change should be evaluated in its own cultural and technological terms.

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