PRELIMINARY CULTURAL IMPLICATIONS FROM INITIAL STUDIES OF THE CERAMIC TECHNOLOGY AT BAN CHIANG

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Excavations at Ban Chiang by The University Museum, University of Pennsylvania and the Thai Fine Arts Department in 1974 and 1975 produced a total of over 440 whole or partially reconstructable pottery vessels, 326 of which were associated with a human burial. In addition, there are many other ceramic artifacts including whole or parts of 85 crucibles, 80 anvils, over 200 rollers, plus bracelets, pellets and spoons. While the metals from the site of Ban Chiang have received considerable attention (White 1982, 1988; Higham 1984), it is actually the ceramic assemblage that is the largest, most complex and potentially the most revealing data set from the site. This rich data set may also allow the examination of levels and changes in craft production and specialization - an effort which has the potential to lend valuable insights into prehistoric social, political and economic development (Peregrine 1991; Underhill 1991).

The burial pottery has formed the basis of the chronological subdivision of the site's 3-4000 year sequence (White 1986). Ten ceramic phases (I-X) have been defined within three periods, Early, Middle, and Late (EP, MP, and LP). As we have become more familiar with the ceramic assemblage, its formal diversity has become very evident, even while suggesting an overall continuity in the aesthetic and morphological traditions. This diversity in turn has raised a number of technical questions. How were the pots constructed and fired? How was the color variation achieved? What were the tempering practices, etc? How might the variability and changes in the ceramic styles, morphology and technology relate to changes in the organization of ceramic production and distribution over time?

These questions became even more interesting as it became clear that the pottery from the nearby site of Ban Na Di was so distinct both stylistically and technologically that it proved difficult to crossdate the ceramics between the two sites (White 1986). Furthermore, since these observations, additional examples of nearby sites with surprising differences in technology and/or material culture have come to light in other parts of Thailand (e.g. Nong Nor and Khok Phanom Di, Higham *et al.* in press; Nil Kham Haeng

Indo-Pacific Prehistory Assn Bulletin 11, 1991:188-203 (P. Bellwood ed., *Indo-Pacific Prehistory 1990*, Vol 2)
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and Non Pa Wai, Pigott pers.comm.). Major differences in the material culture among contemporary sites in close proximity raise questions about cultural and technological relationships among prehistoric communities. Assessment of the levels and organization of craft production and distribution at various periods in the region might help to elucidate these questions.

In the early 1980s, the Museum Applied Science Center for Archaeology (MASCA) initiated a small pilot project to examine the ceramic technology of Ban Chiang (McGovern *et al.* 1985; Glanzman and Fleming 1985). Starting with an initial sample of 12 vessels, this study addressed the raw materials and manufacturing methods used in pottery vessels from the Early, Middle and Late Periods. This pilot study has since been modestly expanded with a focus on the Early and Middle Periods.

Preliminary results are available from the expanded study including petrography by Andy Pelcin, xeroradiography by William Glanzman and neutron activation by Stuart Fleming and Ron Hancock. Preliminary results from William Vernon's technical analysis of the crucibles are also available. The cultural meaning of many of the findings is not yet clear but some of the preliminary findings seem to have particular significance. We would like to stress that we are still in an exploratory stage.

PETROGRAPHY

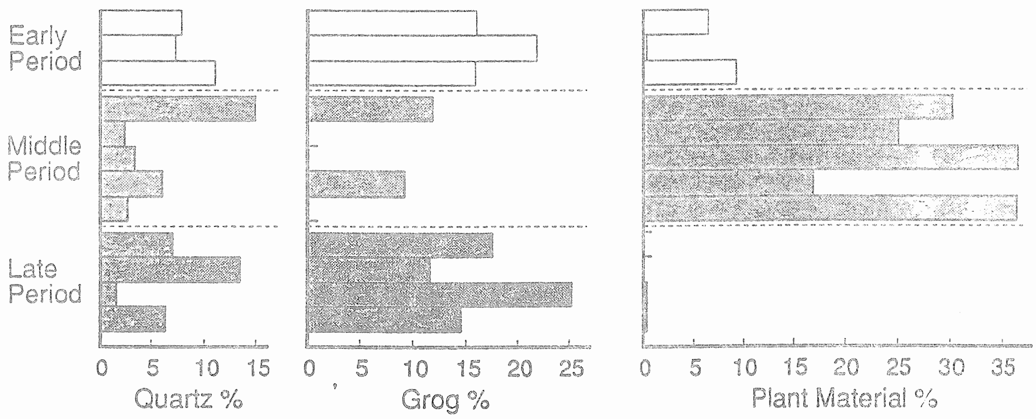


FIGURE 1: HISTOGRAM OF QUARTZ, GROG AND PLANT INCLUSIONS IN THE TWELVE VESSELS IN THE PILOT STUDY, SHOWING DISTINCTIVE PATTERNS AMONG EARLY, MIDDLE AND LATE PERIOD VESSELS IN THE LIMITED SAMPLE

The expanded petrographic study which examined thin sections from an additional 27 vessels essentially supported the pilot study of 12 vessels (Fig. 1) in which each period had distinctive petrographic profiles, although there were a few anomalous vessels. Fleming notes that there was an "incredible consistency" in the EP II-IV corpus which tended to have less than 20% of quartz, grog or plant material; inclusions tended to be about 0.1 mm. The most notable change is a marked increase in unmodified plant temper in the

Middle Period and its immediate decline in the Late Period. This study has not duplicated that of Vincent (1988) and we currently plan for Brian Vincent to come to The University Museum to conduct more in-depth studies on the Ban Chiang ceramics during the summer of 1992.

INAA

The elemental fingerprints of 96 vessels were studied using Induced Neutron Activation Analysis (INAA). A typical compositional pattern was defined for each of the three Periods. Six of the vessels in the corpus, however, displayed anomalies in their composition, three in their main constituents, three in their trace element content.

In general, the EP-to-MP transition is marked by a significant decrease in all but three elements (potassium, calcium, and rubidium). The increase in potassium content probably arises from addition of high levels of plant temper during the MP. The increase in calcium content is not yet explained.

For reasons as yet to be determined, the sodium content shows the most marked decrease, of 56%. This may be related to clay source in that salt deposits are common but localized in northeast Thailand. The general decrease in main and trace element contents, EP to MP, is around 24%, which is statistically significant. However, such broad content decreases can be a direct function of increased and consistent use of quite pure temper of some kind. As with the potassium content variation mentioned above, it currently seems most reasonable to suggest that the EP-MP decreases are due to the use of appreciable amounts of plant tempering during the MP rather than any change of clay resource.

The MP-to-LP transition is marked by a recovery to at least the EP levels in all but two elements (sodium and hafnium). Again the sodium content variation cannot yet to be fully explained. The present data for the LP vessels is consistent with (i) the move away from the use of plant materials as temper, and (ii) the increased amount of hematite in the temper during that Period, as outlined in the limited scope study of McGovern *et al.* (1985).

The INAA rare earth analysis revealed no significant variation among the specimens.

VESSEL MANUFACTURE

Bill Glanzman, who undertook the fabrication study, is interested in identifying "potting traditions", which he considers a product of the sum total of learned behavior that a potter has applied to the creation of a certain vessel, from mining the clay to the final firing. The elucidation of the four general stages of pottery manufacture - formation of the clay body, shaping, surface treatment and firing - is critical to defining and understanding any potting tradition. While not all of those actions are manifest in the archaeological product, the more complete the vessel the greater will be the yield of information. Thus, sites with significant long term mortuary deposits like Ban Chiang, which produce ample relatively complete or restorable vessels, can greatly contribute toward defining prehistoric potting traditions.

While sometimes remnants of the various stages of vessel manufacture can be identified on the vessel's surface, often each successive technique may mask a previous step. For example, a coil-built pot may receive extensive smoothing, beating, or burnishing which may obliterate all macroscopically visible traces of coil building maneuvers. In this case mere visual examination of the vessel will yield very little information about the manufacturing method and thus greatly impair one's ability to reconstruct the potting tradition. The paddle and anvil technique, which was present throughout the sequence and is even employed in the present, probably obscured much of the macroscopically visible evidence for vessel building.

In addressing this problem, the use of xeroradiography to study manufacturing techniques for the building of the Ban Chiang pottery vessels has been particularly productive. Enhanced X-ray imaging, used primarily in detecting breast cancers (i.e. mammography), was applied to vessels to produce blue xeroradiographic images. These images reveal strikingly clear pictures of the internal structure of a vessel despite intensive surface treatment. Xeroradiographic images can reveal the presence of anvil impressions and joins in clay segments. The join between various clay segments such as coils can be seen as a horizontally aligned, laminar flow of the air pockets created whenever two or more clay segments are joined together. In cases where severe surface deformation has occurred, these joins may not be detectable at all. The ubiquitous corded paddle and anvil technique of sidewall shaping and occasional burnishing frequently obscured fabrication procedures that were revealed in the xeroradiographs.

The pilot study of fifteen vessels identified only two basic methods of vessel construction, coil-and-slab and lump-and-slab. That is, upon a circular base or "slab", either coils or a single cylinder (termed a lump) were attached and then the whole was shaped by beating with a paddle and anvil.

After this pilot study was conducted, Vincent (1984:661) pointed out that over 90% of locally made vessels from the main mortuary phase (MP1) at the nearby site of Ban Na Di had molded bases indicated by positive impressions of cordmarking on the interior of the base of the pot, presumably from the base of a pot that served as a mold. No example of this was found during our initial study of 15 vessels. The expanded study did, however, reveal some molded bases.

In the expanded study, of a total sample of 59 vessels studied to date (41 from EP, 11 from MP and 7 from LP), at least seven techniques of vessel building were identified. The four major methods include two types of coil-and-slab, lump-and-slab and molded-base with coils. In addition, rare examples were found of molded-base with slab, section building and pinching. Several manufacturing methods were used for more than one form, but certain forms were created by only one particular method. These methods will be further described below.

Early Period Coil-and-Slab

The slab with two or more thin coils is the most common vessel construction method among the EP II pots and was used on a variety of vessel types and sizes ranging from

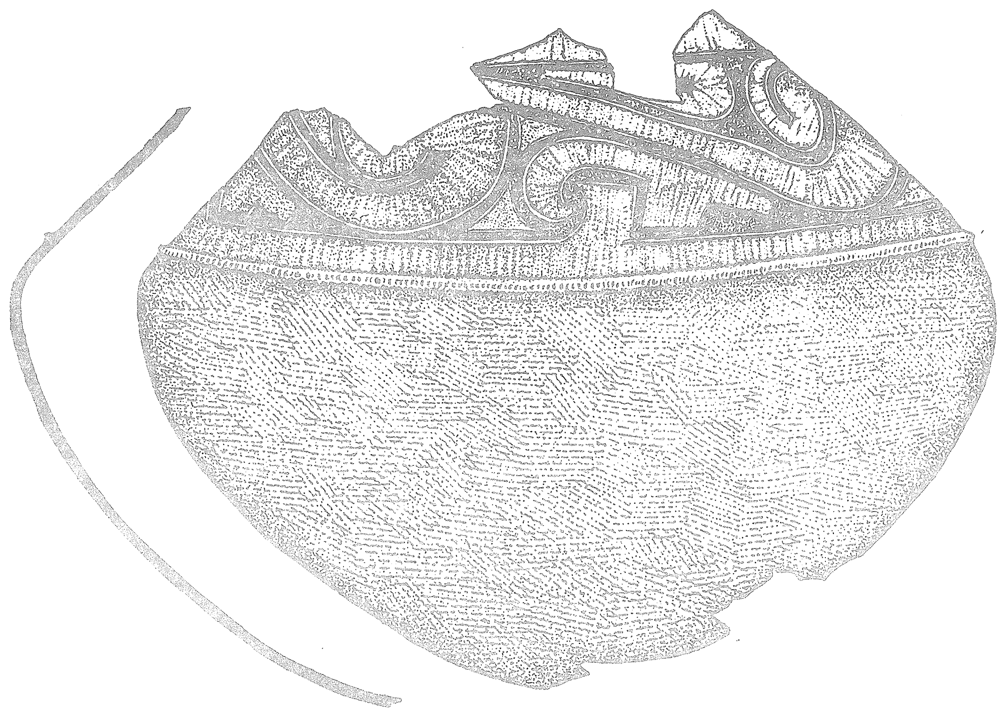


FIGURE 2: COIL-BUILT DENSELY INCISED EARLY PERIOD II VESSEL (H. 33 CM)

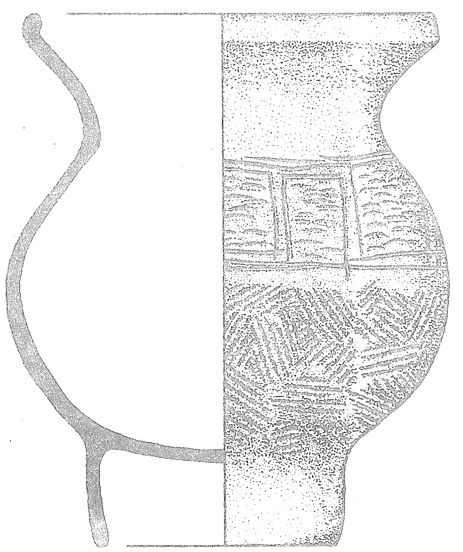


FIGURE 3: COIL-BUILT EARLY PERIOD II FOOTED VESSEL (H. 20 CM)

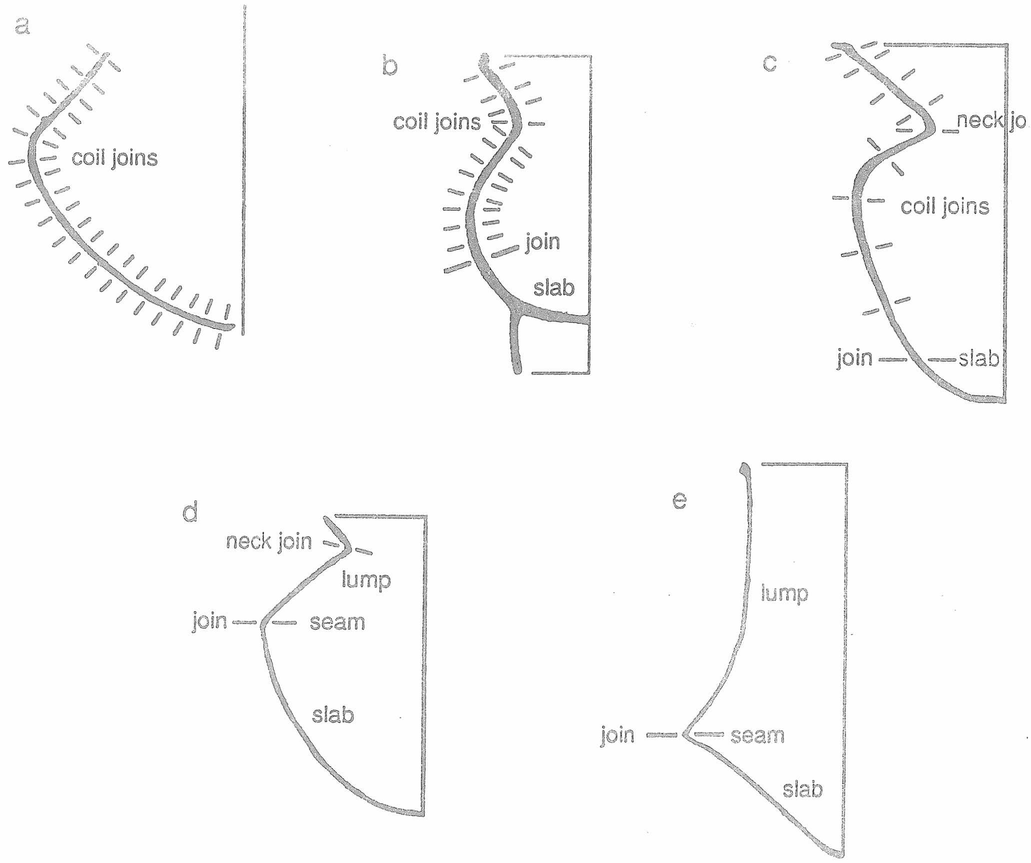
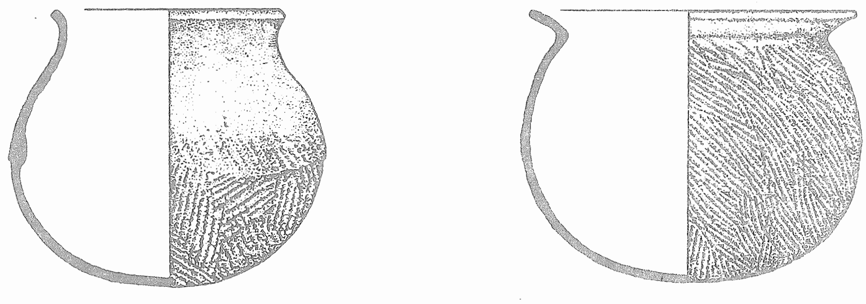


FIGURE 4: TECHNIQUES OF VESSEL BUILDING

a, b, thin coil-and-slab common in the Early Period (same vessels as Figs 2 and 3); c, thicker coil-and-slab common in the Late Period (same vessel as Fig. 9); d, e, lump-and-slab on Middle Period carinated vessels (same vessels as Figs. 7 and 8)



FIGURES 5 AND 6: MOLDED BASE VESSEL (H. 11.5 CM) (juncture evident where cordmarking abruptly changes direction at midbody); **LUMP-AND-SLAB VESSEL (H. 16 CM)** (whose cordmarking is continuous across the juncture)

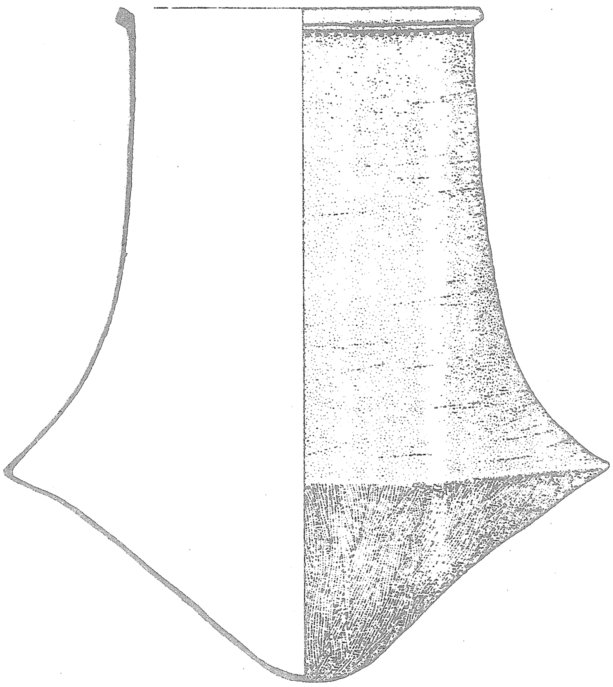


FIGURE 7: LUMP-AND-SLAB VESSEL (H. 45.5 CM) FROM THE MIDDLE PERIOD

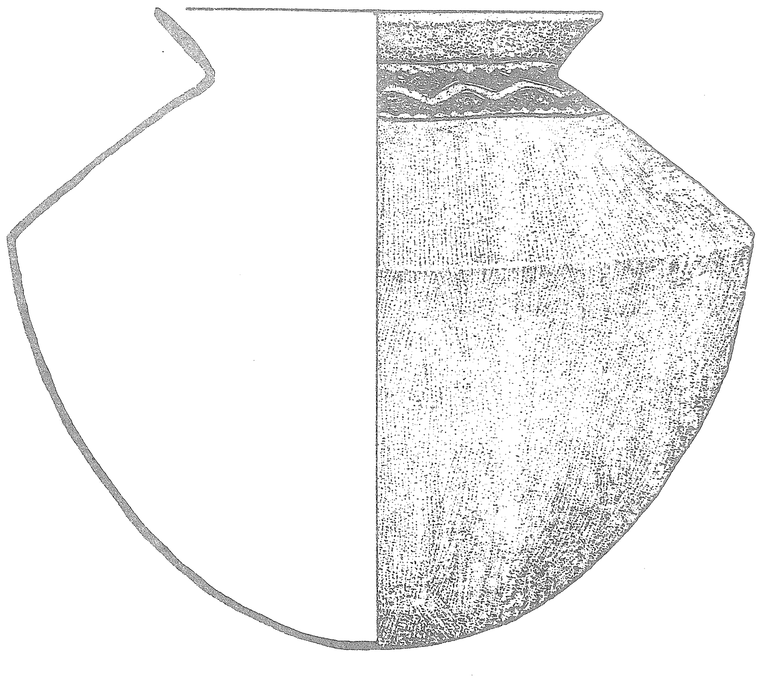


FIGURE 8: LUMP-AND-SLAB VESSEL (H. 34.5 CM) FROM THE MIDDLE PERIOD

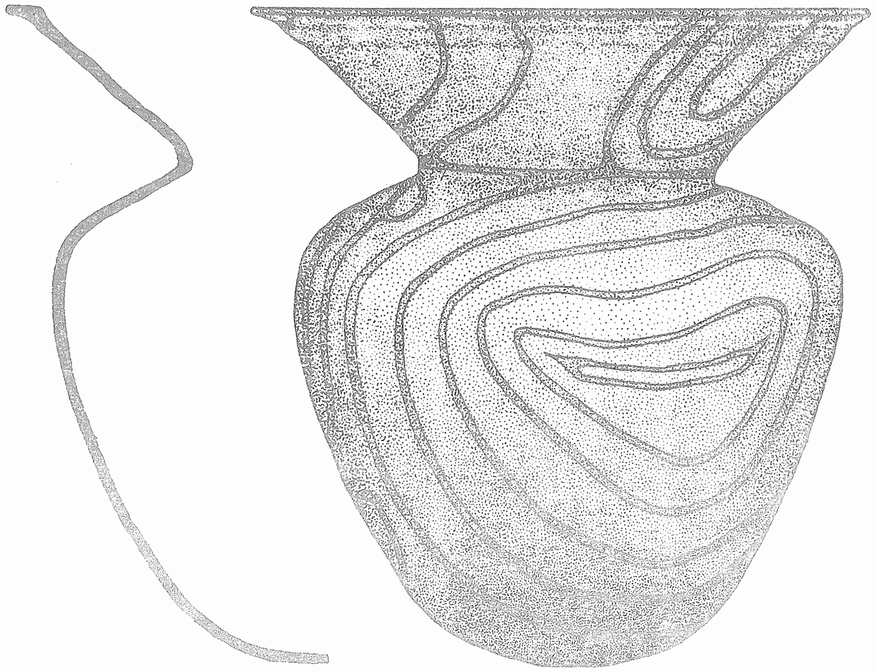


FIGURE 9: COIL-AND-SLAB VESSEL (H. 34.5 CM) FROM THE LATE PERIOD

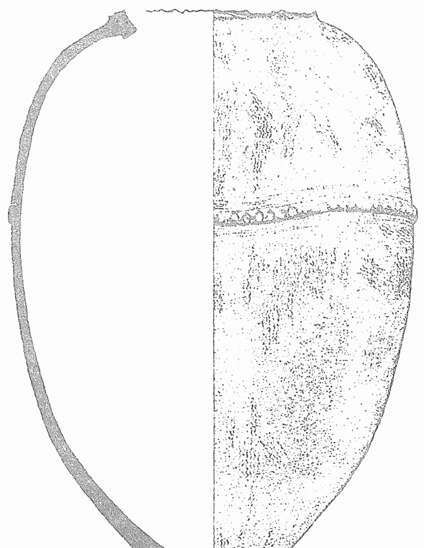


FIGURE 10: SECTION-BUILT INFANT BURIAL JAR (H. 43.5 CM) FROM THE EARLY PERIOD

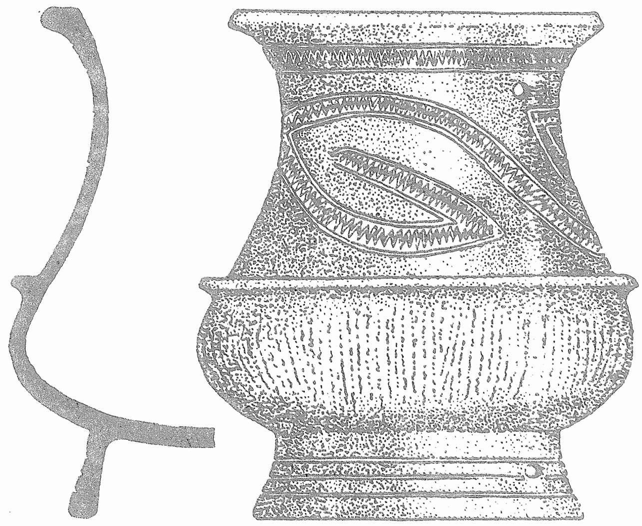


FIGURE 11: EARLY PERIOD I BLACK INCISED VESSEL (H. 15.4 CM)

large incised infant burial jars to small globular pots (Figs 2, 3, 4a, 4b). One of the infant burial jars has at least 16 coils. Xeroradiographic coil heights for most of the vessels made in this way tend to be around 2 cm. The top edge of each thin coil is flattened and there is always a downward smearing of clay on the interior of the vessel at the uppermost added coil. Sometimes the coil joins are macroscopically visible, occasionally on the pot exterior, more commonly on the vessel interior.

There are anvil impressions on the interior surface of these vessels including the lower body zone, but not on the very bottom of the interior (where extant). Two of the slab bases are intact and had diameters measuring 8.0 and 9.0 cm. While most common during EP II, this method has also been identified as late as the Middle Period.

Molded-Base with Coils or Lump

Most of the examples of molding come from Early Period contexts, although two Late Period bowls (discussed below) appear to be made from a single molded slab without body extensions. Most of the bases which have been molded, i.e. pressed apparently over another cordmarked pot, have body extensions, usually of coils, and in two cases of a single lump. The interior of the lower bodies of all the molded-base vessels retain areas that carry positive impressions of corded paddle marks, presumably from the surface of the mold over which the base was pressed. The orientation of the interior impressions (i.e. criss-crossed) suggest that the mold was itself a vessel whose basal exterior has been thinned out with a corded paddle in a paddle-and-anvil maneuver.

The appearance of the join between the molded-base and the upper body or rim depends upon the kind of surface treatment applied and that treatment's intensity. The location of the join between the molded-base and the upper body is often evident from an abrupt transition in the external impressions of the corded paddle which was used in the shaping stage of these Ban Chiang vessels. Usually the impressions on the molded-base's exterior criss-cross from the bottom of the base all the way up to the top edge of the molded component; thereafter they are oriented more linearly (Fig. 5). In contrast, the exterior cordmarking on lump-and-slab, and coil-and-slab vessels is usually continuous across the join (Fig. 6). Examination of the interior of molded-base vessels may also reveal the join; in one case the interior retains the evidence of clay that has been smeared downward from the surface of the first applied coil over the top edge of the molded component. In other instances wet-smoothing and scraping maneuvers subsequent to the construction stage were so intensive that only traces of the mold's impressions remain.

Anvil impressions, where detectable, are restricted to the upper body components of vessels with molded-bases. In contrast, anvil impressions on the interior of the coil-and-slab vessels are more widely distributed.

Lump-and-Slab

The lump-and-slab method was also found from the early Early Period with an occasional example until EP V. The technique was especially prominent in the Middle Period when it was artfully developed in the magnificent Middle Period carinated wares (Figs 4d, 4e, 7, 8). Xeroradiographic analysis demonstrated the absence of coil construction for the body and also demonstrated the joining of the cones along the carination at the vessel's greatest diameter. Macroscopic examination of the interior demonstrates the frequent presence of an applied strip or patching coil at that angle, presumably to secure the join better. The presence of numerous, tightly packed anvil impressions on both segments demonstrates that the vessel went through intensive shaping using the paddle and anvil technique. The thinness and evenness of the side walls indicates a masterful level of potting technique (Raymond Rorke, potter, pers. com.).

Late Period Coil-and-Slab

During the Late Period, a new kind of coil-and-slab technique takes precedence and no examples of lump-and-slab have yet been identified. The edges of the coils are always rounded, not flat like earlier coils, and they vary in height (Figs 4c, 9). The overlap on the interior between adjoining coils is substantial and only partially smoothed over. The manufacture overall is rather crude, resulting in large, thick forms, many of which bear a wide painted field.

Additional Techniques

In addition to the four major approaches to vessel building, there are several singular examples such as single molded slabs and pinch-pot variants. Two Late Period vessels retain traces of leaf impressions on their bottom and side wall surfaces suggesting that they were first paddled into a slab of required thickness (leaving corded paddle impressions on the exterior of the bottom) and then press-molded in one case into, in another case over, a shallow concave mold that had been lined with organic material (leaves and perhaps palm fronds).

Perhaps the most unusual vessel in the Early Period sample was an infant burial jar (Fig. 10). Its sidewall consists of two "coils" so deep (7 cm and 11 cm respectively, versus an average coil depth of about 2 cm on multi-coil bodies) that the manufacture could be regarded as starting as lump-and-slab, with the sidewall being subsequently raised by addition of an extra lump (i.e. "section-building").

Some Interim Comments on Vessel Manufacture

An important point to make is that no single method was used exclusively during any phase; all major variants have examples from the earliest phases. These manufacturing methods overlap in time, especially during the Early Period, often being present in the same grave. Certain forms may be made with more than one method, such as the small globular cordmarked vessel which has examples of both coil and lump body extensions on both molded-bases and unmodified slabs. Glanzman sees this as several coexisting potting traditions each of which enjoys some longevity.

The variation in vessel construction raises several questions about the organization of ceramic production and distribution in prehistoric northeast Thailand that will be further investigated in forthcoming research. Glanzman, however, has made several interim observations that can serve as hypotheses for future testing. The great variation in both vessel morphology and surface treatment associated with the coil-and-slab method during the Early Period is consistent with unspecialized production. Hence one might suggest (following David Peacock 1982) a "household" level of production, the products of which were produced and intended for consumption by a household unit. Vessels from such a production mode tend to reveal significant morphological variation, even for forms whose function is the same. (Interestingly, one reason for the lack to date of a comprehensive pottery typology for Ban Chiang is the high proportion in the assemblage of unique vessel shapes and sizes).

On the other hand the large, bulbous coil-and-slab vessels from EPII with intricately and densely incised shoulders (Fig. 2) are quite complex, labor intensive and extremely well executed. These and the beautifully made earliest EPI Ban Chiang pottery (Fig. 11) suggest a well established potting tradition whose products reflect considerable effort beyond functional needs. Glanzman proposes considering an "individual workshop" level of production, in which some level of craft specialization has evolved such that the products of a workshop are intended for consumption outside of the household unit. These observation suggest the possibility that household and individual workshop production levels coexisted from the earliest phases.

The exclusive and highly refined use of the lump-and-slab method for the elegant Middle Period white carinated vessels must surely attest to some level of specialized production. The basic method, however, is present in Early Period II. The lump-and-slab method is not regionally preferred, however, as shown by the nearby site of Ban Na Di, 20 km distant from Ban Chiang. Ban Na Di's main mortuary deposit overlaps Ban Chiang from about Early Period V through the Middle Period. During this period, when at Ban Chiang the lump-and-slab strongly predominates, at Ban Na Di the molded-base was used in over 90% of the grave vessels from the main mortuary phase and these vessels usually have an upper body made of coils. Only 2 of 13 vessels in the Ban Chiang sample from the same time period have molded bases and only one of these has an upper body of coils. These fabrication differences between the two sites are paralleled by major differences in decorative styles as well. Clearly the prevalent potting traditions at the two sites were quite distinct.

During the Late Period, surface design creativity and variability flourished while the manufacturing technique seems to have been relatively regularized. The reasons for this design explosion are not clear, but Longacre, Skibo and Stark (1991; also Stark 1991) found that when pottery manufacturing among the Kalinga made a transition from a household to a community specialty, during a period of marked increase in external trade contacts from outside the region, there was a burst of ceramic creativity and design elaboration. New forms and highly individualized decorative treatments abruptly appeared within a few years. Testing for a comparable situation in the late first millennium BC in northeast Thailand might be a fruitful avenue for future research.

In summary, the preliminary xeroradiographic research done to date shows this technique to have great potential for addressing issues surrounding ceramic production. Vessel fabrication appears to vary synchronically and diachronically within the Ban Chiang ceramic assemblage and from site to site as well. Comprehensively investigating the regional variation in vessel fabrication may help elucidate the area's development of site specialization (Rice 1987:187) in craft production hypothesized by White (1986:314), and contribute to understanding the prehistoric trade networks in ceramics discussed by Vincent (1988).

CRUCIBLES

Analysis of the crucibles is also revealing information about pyrotechnology and degree of village specialization in the production of metals. William Vernon became interested in the Ban Chiang crucibles after conducting a study of the crucibles from the mining site of Phu Lon in Loei Province (Vernon 1988, Pigott *et al.* 1985). The Ban Chiang corpus consists of about 85 specimens ranging in size from small pieces to whole or nearly whole crucibles found from possibly as early as EP II to Late Period contexts. Unlike the grave pottery, the crucible technology reveals a relative consistency over large regions and long time spans.

The fabric of the crucibles is being analyzed by means of petrographic analyses of thin sections, heavy mineral analyses and individual grain studies. Initial studies show that a fine gray clay with quartz inclusions constitutes the majority of pieces. Vitrification, slag and multicolored glass are characteristic features of many of the fragments, and secondary copper minerals are fairly common. Prills are scarce and very small. These, as well as the glass and slag, are being mounted for SEM, EDS and PIXE analyses to provide information on raw materials and the nature of the metals produced. Prills, chiefly copper and bronze, will also be subjected to metallographic analyses.

On the whole the technology of the crucibles reveals a sophisticated grasp of pyrotechnology. Ninety-five percent of the pieces have rice chaff or organic temper of varying amounts. The voids produced by burning out the rice chaff would inhibit the formation of cracks in the ceramic body under high heat, enabling the crucibles to survive the melting/smelting process. Other significant aplastic constituents are quartz grains, rock fragments, fired clay fragments, and crushed and sized pieces of slag. The presence of slag as temper increases the refractory nature of the fabric since it has already been fired and resists further changes. Vernon found that slag comprised 1-2% of the clay body of some crucible fragments. This recipe may have allowed the crucibles to survive the melting process intact and be reused.

The clay paste has an abundance of tiny quartz grains, mostly in the range of 0.1 to 0.3 mm in diameter. Many of these grains have magnetite inclusions which is a signature for the quartz itself. These quartz grains are likely to have been an original constituent of the clay and not a deliberate aplastic addition. This makes the clay itself a highly refractive material for crucible manufacture.

Of particular interest is the recurrent evidence for lagging, that is the application of an insulating layer to the interior of the crucible. Seventy percent of the pieces show evidence of interior lagging, from small remnant patches to nearly complete coverage. The thin, lagged layers consist of fine quartz-rich sand with a clay binder. Preliminary observations indicate that in most cases the quartz sand in the lagged layer has the same characteristics and mineral inclusions as the sand in the clay paste, and in all other respects the quartz grains seem to be identical to those in the clay paste. It is noteworthy that minerals other than quartz are extremely rare, which would not normally be the case in most sand deposits. Therefore, it is suggested that sand for the lagged layers comes from washing the same clay that is used in the crucible manufacture. The unusual purity of the quartz layer would make it highly refractive.

This lagged layer is not bonded to the crucible and can be scraped off. If the lagged layer is present, there is a tendency for melting/smelting products to be incorporated into that layer, which would facilitate removal of the product. If a lagged layer is missing, there is a tendency for the metal to be incorporated into the body of the crucible. The lagged layer was not fired prior to its use for smelting or melting. The lagging indicates an understanding of sophisticated refractory principles, since the layers would tend to reflect heat and retard crucible disintegration during the smelting process.

Most noteworthy are several cases where more than one lagged layer is separated by slag indicating re-use of the crucibles. We believe it has been a general assumption that prehistoric Thai crucibles were used once, then broken open to retrieve the metal contents. This might account for the high proportion of crucible fragments relative to whole crucibles. For example, at the mining site of Phu Lon no whole crucibles were found among the approximately 100 fragments (Vernon 1988). In general, though, initial studies of the Ban Chiang crucibles and fragments reveal a technology strikingly similar to crucibles made and used for bronze manufacture at the mining site of Phu Lon in Loei province, 100 km to the west of Ban Chiang (Pigott and Natapintu 1988). The few crucible fragments from the sites of Ban Tong, Ban Phak Top and Don Klang are also similar.

One exception, however, is that the Phu Lon crucibles seem to be smaller than those found at Ban Chiang. Vernon proposes that the Phu Lon crucibles were only capable of producing small amounts of metal. Despite the relatively large capacity of the Ban Chiang crucibles, they are not large enough to hold the quantity of metal needed for the production of the larger objects, such as axes, in the prehistoric bronze repertoire of Southeast Asia. Interestingly, only one axe has been excavated from Ban Chiang; no complete mold sets or even a complete half mold were found. Ban Na Di also produced little evidence that axes were cast at the site (Higham and Kijngam 1984), suggesting that there must have been a larger operation elsewhere.

A possible example of a site specializing in axe production might be Non Nok Tha, where numerous axes and complete bivalve sandstone mold sets have been retrieved (Bayard 1980). The site of Non Pa Kluay (Wilen 1989:52) also produced several axe molds. To support the possibility that sites specialized in production of larger cast items such as axes, it would be important to know if the crucibles from Non Nok Tha and Non Pa Kluay tended to be larger than those from Phu Lon or Ban Chiang, and had a capacity suitable for melting the large amount of metal needed for axes. If so, there might have been more complex differential specialization in metal production than formerly assumed. In addition to primary production sites like Phu Lon, the manufacturing sites might have been differentiated by items cast and level of expertise. Sites like Non Nok Tha might have specialized in casting axes which also were hammered and annealed to strengthen the edge. Sites like Ban Chiang and Ban Na Di might have cast only the simpler items - the ubiquitous bangles and bracelets for which post-casting treatment is rarely found (White 1988; Stech and Maddin 1988; Seeley and Rajpitak 1984:106). These bracelets seem to have been cast by the lost wax method using clay molds. Notably, there is a dearth of stone resources in the central Sakon Nakon Basin, but Bayard (1980) has argued that the source for the stone in the Non Nok Tha sandstone molds would have been locally available.

Vernon notes that, based upon his field observations, the crucibles of Northeast Thailand appear to be completely different in terms of morphology, size, fabric and thickness from those found in the Central Thai site of Non Pa Wai (Pigott and Natapintu 1988); the Ban Chiang crucibles are thinner and more fragile. The detailed study of the differences should reveal more about evolution and differentiation in technology and craft specialization in the Southeast Asian Metallurgical Province (White 1988).

SUMMARY

In summary, the preliminary technological evidence on Ban Chiang ceramics provides tentative support for the view that potting traditions in prehistoric Northeast Thailand show markedly localized development while the metals technological complex appears to crosscut stylistic and technological potting spheres. We feel that the crucible evidence supports and elaborates the concept of the proposed Southeast Asian Metallurgical Province (White 1988). The metals-related complex is a broadly shared technology requiring specialization, interregional exchange and trade possibly from its inception, yet the ceramic production and technology appear to remain localized until late in the prehistoric sequence. The implications of coexisting levels of craft production for the development of trade and socio-political complexity will surely be worth exploring.

REFERENCES

Bayard, D. T. 1980. An early indigenous bronze technology in northeast Thailand: its implications for the prehistory of East Asia. In H. H. E. Loofs-Wissowa (ed.), *The Diffusion of Material Culture*, pp. 191-214. Asian and Pacific Archaeology Series 9. Honolulu: Social Science Research Institute, University of Hawaii.

Glanzman, W. D. and Fleming, S. J. 1985. Ceramic technology at prehistoric Ban Chiang, Thailand: fabrication methods. *MASCA Journal* 3:114-121.

Higham, C. F. W. 1984. The Ban Chiang culture in wider perspective. *Proceedings of the British Academy* 69:229-261.

Higham, C. F. W. and Kijngam, A. 1984. *Prehistoric Investigations in Northeastern Thailand, Parts I-III.* Oxford: BAR International Series 231 (i-iii).

Higham, C. F. W., Bannanurag, R., Boyd, W., Higham, T., Mason, G. and Tayles, N. in press. Human adaptation to a subtropical coast: excavations at Nong Nor, Central Thailand.

Longacre, W., Skibo, J. and Stark, M. T. 1991. Ethnoarchaeology at the top of the world. *Expedition* 33(1):4-15.

McGovern, P. E., Vernon, W. W., and White, J. C. 1985. Ceramic technology at prehistoric Ban Chiang, Thailand: physiochemical analyses. *MASCA Journal* 3(4):104-113.

Peacock, D. P. S. 1982. *Pottery in the Roman World: an Ethnoarchaeological Approach*. London: Longman.

Peregrine, P. 1991. Some political aspects of craft specialization. *World Archaeology* 23(1):1-11.

Pigott, V. C., Natapintu S. and Theetiparivatra, U. 1985. Research in the development of prehistoric metal use in northeast Thailand. To be published among the proceedings of the "Research Conference on Early Southeast Asia," Bangkok and Nakon Pathom, 8-13 April 1985.

Pigott, V. C., and Natapintu, S. 1988. Investigating the origins of metal use in prehistoric Thailand. To be published among the proceedings of the "Conference on Ancient Chinese and Southeast Asian Bronze Age Cultures," Kioloa, New South Wales, 8-12 February 1988.

Rice, P. M. 1987. *Pottery Analysis: a Sourcebook.* Chicago: University of Chicago Press.

Seeley, N. and Rajpitak, W. 1984. The bronze technology. In C. F. W. Higham and A. Kijngam, *Prehistoric Investigations in Northeastern Thailand, Part I,* pp. 102-112. Oxford: BAR International Series 231.

Stark, M. T. 1991. Ceramic production and community specialization: a Kalinga ethnoarchaeological study. *World Archaeology* 23 (1):64-78.

Stech, T. and Maddin, R. 1988. Reflections on early metallurgy in Southeast Asia. In R. Maddin (ed.), *The Beginnings of the Use of Metals and Alloys*, pp. 163-174. Cambridge: M.I.T. Press.

Underhill, A. P. 1991. Pottery production in chiefdoms: the Longshan period in northern China. *World Archaeology* 23(1):12-27.

Vernon, W. W. 1988. The crucible in copper/bronze production at prehistoric Phu Lon, northeast Thailand: analyses and interpretation. To be published among the proceedings of the "Conference on Ancient Chinese and Southeast Asian Bronze Age Cultures," Kioloa, New South Wales, 8-12 February 1988.

Vincent, B. 1984. The petrographic analysis of prehistoric pottery from Ban Na Di and related sites. In C. F. W. Higham and A. Kijngam (eds), *Prehistoric Investigations in Northeast Thailand, Part III*, pp. 644-697. Oxford: BAR International Series 231.

----- 1988. *Prehistoric Ceramics of Northeastern Thailand, with Special Reference to Ban Na Di.* Oxford: BAR International Series 461.

White, J. C. 1982. *Ban Chiang: Discovery of a Lost Bronze Age.* Philadelphia: The University Museum, University of Pennsylvania and the Smithsonian Institution Traveling Exhibition Service.

----- 1986. *A Revision of the Chronology of Ban Chiang and its Implications for the Prehistory of Northeast Thailand.* Ph.D. dissertation, University of Pennsylvania. Ann Arbor: University Microfilms.

----- 1988. Early East Asian metallurgy: the southern tradition. In R. Maddin (ed.), *The Beginning of the Use of Metals and Alloys*, pp. 175-181. Cambridge: M.I.T. Press.

Wiien, R. N. 1989. *Excavations at Non Pa Kluay, Northeast Thailand.* Oxford: BAR International Series 517.