A CHARACTERIZATION OF MORTUARY CERAMICS FROM BAN NON WAT, NORTHEAST THAILAND

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ABSTRACT

After numerous seasons of excavation, a long sequence of occupation was revealed at Ban Non Wat in Northeast Thailand from the Neolithic to the Iron Age. This paper provides the results of a characterisation of ceramic vessels identified in burial contexts. The studied sample includes Bronze and Iron Age ceramics. The analysis involved a characterisation of morphology, surface treatment and fabrics, in order to understand the technology for pottery manufacture at Ban Non Wat. The fabric characterisations of the clays and tempers were conducted with electron microprobe analysis. The results revealed two distinct manufacturing methods in terms of temper selection. The Bronze Age phase 2 and 3 burials were tempered with sand in almost all of the studied sherds, while fibre tempered ceramics were dominant in the assemblage in burials from Bronze Age phase 4 to the Iron Age phases. The adoption of fibre tempering appears to have taken place between Bronze Age 3 and 4 at Ban Non Wat, positing the earliest dated use of this method on the Khorat Plateau during the Bronze Age at c.800 BC. The known presence of fibre temper in ceramics amongst Neolithic assemblages from Ban Non Wat and elsewhere indicates earlier uses of this technology in the region and discontinuity between Neolithic and Bronze Age temper choices by potters.

INTRODUCTION

Excavations at Ban Non Wat, Northeast Thailand, over the last seven years have revealed 637 burials across ten mortuary phases. The sequence covers Neolithic, Bronze and Iron Age occupation over a 2000 year period, an unprecedented situation in Southeast Asia. Seventy five radiocarbon determinations have identified a precise chronology for the cultural sequence at Ban Non Wat (Higham and Higham 2009). The archaeological remains include over 4000 complete pottery vessels, 336 clay anvils and 109 burnishing stones, suggesting the local manufacture of ceramic wares. This paper presents a characterisation of ceramic form and fabric from the early Bronze Age to the Iron Age, utilising morphological and physico-chemical analyses. It considers the location of the observed technological developments within a context of regional change in ceramic manufacture.

BAN NON WAT

Ban Non Wat is a moated prehistoric site in the upper Mun Valley of the Khorat Plateau, Northeast Thailand. It is situated near other prehistoric sites in proximity to the Chi and Mun Rivers, which are tributaries of the Mekong River (Figure 1). The Khorat Plateau was most likely an area of slightly disturbed native forest, with some rice cultivation, from the Bronze to early Iron Age (Boyd and McGrath 2001:323). Ban Non Wat was excavated under the direction of Professor Charles Higham (University of Otago, Dunedin), Dr Rachanie Thosarat (formerly of the Thai Fine Arts Department, Bangkok), and Dr Amphan Kijngam (Thai Fine Arts Department, Bangkok), as part of the Origins of the Civilisation of Angkor project.

Radiocarbon dates from the Oxford Radiocarbon Accelerator Unit on shell and charcoal have resulted in a convincing chronology for the Ban Non Wat sequence (Table 1). These dates have provided the first reliable chronology for the Northeast Thailand Neolithic to Iron Age sequence (Higham and Higham 2009). The dating of Southeast Asian prehistory has a contentious history, particularly for the first appearance of bronze (see Higham 1996:9-12; Higham, Higham and Kijngam 2011; White 1986, 1997:104, 2006; White and Hamilton 2009).

METHODOLOGY

This paper characterises vessel form and fabric changes in ceramic technology through time at Ban Non Wat. This study was restricted to Bronze Age (phases 2 to 5) and Iron Age (phases 1 and 2). Neolithic and Bronze Age 1 vessels were not sampled. Ceramic sherds were collected from the excavation material of the 2005 to 2006 and 2006 to 2007 field sea-

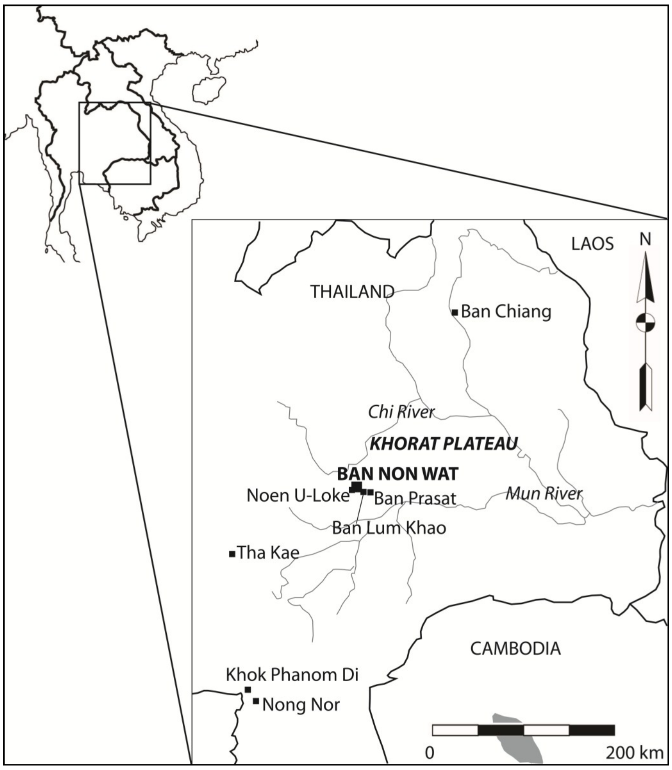

Figure 1. Map of Ban Non Wat's location.

sons. In total, 123 ceramic vessels were sampled. When possible, more than one sherd was collected from each vessel: one from the upper portion and one from the lower. These sherds were transported to New Zealand for analysis with an electron microprobe in the Geology Department of the University of Otago, Dunedin.

The electron microprobe was employed to analyse the ceramic fabrics, including the chemical compositions of the potting clays and non-plastic inclusions (Summerhayes 2000). The minerals were identified from chemical compositions, after Deer *et al.* (1966). The electron microprobe was chosen for this analysis because of its utility in chemical and visual analyses of the ceramic fabrics. Commonly employed methods in ceramic analysis yield either chemical results (particle induced X-ray and gamma-ray emission, instrumental neutron activation analysis, X-ray fluorescence and X-ray diffraction) or optical results (thin section petrography). Some tempers used in ceramic manufacture in Southeast Asia are of botanical origin and cannot be analysed chemically. Instead, they must be identified visually. Commonly, petrography has been used—independently from the chemical analysis of the clay matrix—for such identifications (e.g. Vincent 1988, 2004; Voelker 2002, 2007). While conducting the chemical analysis of the clay matrices and mineral contents, temper, grain size, and textures were observed visually through the electron microprobe. By reducing cost and time, the electron microprobe probe proved suitable for completing the chemical analysis and temper characterisation.

The initial step involved arranging the sampled ceramic vessels chronologically according to the burials they were associated with. Higham categorised each burial into a phase: Bronze Age 1, 2, 3, 4 or 5 and Iron Age 1 or 2, based on mortuary goods, burial orientations and treatments, stratigraphic and horizontal positioning, and ceramic forms (Higham and Higham 2009; Higham and Kijngam 2009). These phases were applied in this study. Vessel forms were grouped according to morphological attributes, body and base forms, vessel heights, and maximum body widths. Cord-marking, burnishing and other surface treatments were recorded, along with their position on the vessels. These attributes were recorded in the field—with descriptions and illustrations—and deduced from photographs of reconstructed vessels.

Scientific analysis of fabrics was conducted on all of the sampled vessels, following sherd preparation in resin briquettes. The pottery was analysed using a JEOL Superprobe JXA-8600 microprobe with an EDS (Energy Dispersive Spectrometry) attachment. Machine conditions used a negative potential of 15KeV accelerating voltage. Backscatter micrographs were taken of the ceramic fabrics at 40, 80, 160 and 600 times magnifications. Non-plastic inclusions--including manually-added tempers and natural mineral grains—and the potting clay matrices were analysed for chemical composition with the EDS. The probe diameter was set at 0 to 20 μm to analyse the inclusions, depending on the size of the inclusion, and at 20 to 30 μm for the clay matrix readings, depending on the density of temper inclusions (which were to be avoided in the analysis of the matrix). This equipment was regularly calibrated and programmed to recognise the concentrations of silicate element oxides that are frequently identified in ceramic fabrics (sodium, magnesium, aluminium, silicon, phosphorus, sulphur, chlorine, potassium, calcium, titanium, vanadium, chromium, manganese, iron, and nickel).

For clay matrix characterisations, the concentrations of each element were recorded from five representative areas.. The concentration values were averaged and subjected to analysis using multivariate statistics. The calculated averages were transformed into logarithm values, and were used as the dataset for a Principal Component Analysis (PCA) in the MVARCH program (Wright 1991). PCA reduces the number of attributes to a few dimensions and transforms the original variables into uncorrelated variables—the principal components—in which the first component should possess the greatest amount of variation, the second component the second greatest, and so on. The first three principal components were calculated and plotted. The fabric characterisations were then ordered chronologically and compared to the vessel form sequence.

Occupational phases	Radiocarbon dates	Mortuary phases	Radiocarbon dates
Neolithic	1650 - 1000 BC	Flexed Neolithic burials	1650 - 1200 BC
		Neolithic 1	1460 - 1410 BC
		Neolithic 2	1060 - 1055 BC
Bronze Age	1000 - 400 BC	Bronze Age 1	1000 - 940 BC
		Bronze Age 2	1000 - 840 BC
		Bronze Age 3	870 - 830 BC
		Bronze Age 4	790 - 740 BC
		Bronze Age 5	? 700 - 400 BC
Iron Age	400 BC - AD 600	Iron Age 1	400 - 200 BC
		Iron Age 2	AD 400 - 600

Table 1. Ban Non Wat occupational and mortuary phases with calibrated radiocarbon dates from Oxford Radiocarbon Accelerator Unit (see Higham and Higham 2009 for complete information on the radiocarbon dates).

There were undetectable quantities of chlorine, sulphur, chromium, nickel and vanadium in the samples, and these elemental oxides were excluded from the PCA. There are known issues with including phosphorus and manganese oxides in the statistical analyses of clay compositional data. Phosphorus can affect the chemical composition of ceramics in post-depositional processes (Freestone, Meeks and Middleton 1985). Additionally, Shepard (1966) has identified manganese as a highly migratory element and caution must be taken in including the element in characterisations and statistical analyses. PCA trials without phosphorus and manganese oxides resulted in increased variability when the samples were plotted, but this process obscured the outliers. The interpretation of clusters did not alter between the inclusion and exclusion of phosphorus and manganese oxides, and these elements were retained for the presented PCA. Thus, the PCA included sodium, magnesium, aluminium, silicon, phosphorus, potassium, calcium, titanium, manganese and iron oxides.

The fabric characterisations were assessed chronologically and compared to the transformations in the vessel form sequence. These findings aimed to identify the prehistoric choices made by potters in ceramic manufacture.

RESULTS

Vessel form groups

In order to separate the ceramic samples into manageable and comparable subsets, and to uncover the relationship between the fabric groups and vessel morphology, nine vessel form groups were identified (Tables 2a and 2b). Many of these forms were identified and categorised at Ban Lum Khao (O'Reilly 2005). These vessel form groups distinguished forms that were associated with the Bronze Age phases from those associated with the Iron Age phases (Figure 2). Bronze Age 2 and 3 burials commonly included restricted vessels with everted rims (form 4). Bronze Age 4 demonstrated some morphological changes, and restricted vessels with everted rims and a carinated oval body dominated the assemblage (form 3). Dramatic morphological transformations occurred in Bronze Age 5 and continued into Iron Age 1 with the appearance of restricted vessels with everted rims or vertical necks and globular bodies (forms 7 and 8). Iron Age 2 vessels displayed an introduction of new forms, such as the Phimai Black unrestricted vessels(form 1e), as well as the continuation of earlier Iron Age forms. Only vessel form 1a, an unrestricted dish, was present throughout the sequence from the early Bronze Age to the late Iron Age.

Temper groups

Six temper groups were identified in the sample, each described and illustrated in Figures 3a and 3b. The non-plastic temper inclusions include quartz sand, fibre, shell, and pottery or fired clay fragments (grog), all in various combinations. Untempered vessels were identified as chemically consistent clay matrices with few larger inclusions. Fibre tempers include all tempers with botanical remains, which are most likely rice chaff.

The distribution of these temper groups through the sequence indicated a marked transition in temper selection during Bronze Age 4 (Figure 4). Bronze Age 2 and 3 ceramic vessels were predominantly tempered with either quartz sand or grog; many were untempered. Bronze Age 4 vessels are distinguishable by the introduction of fibre temper. A single fibre grain, possibly rice, in one Bronze Age 2 vessel was discovered. This anomaly was probably an accidental inclusion. Fibres were usually abundant within the fabrics of fibre-tempered vessels from Bronze Age 4 onwards into the Iron Age. Six vessels from Bronze Age 5 and Iron Age 1 contexts were identified with two tempers in a single vessel: the rim and shoulder sherds were tempered with sand and the body sherds with fibre.

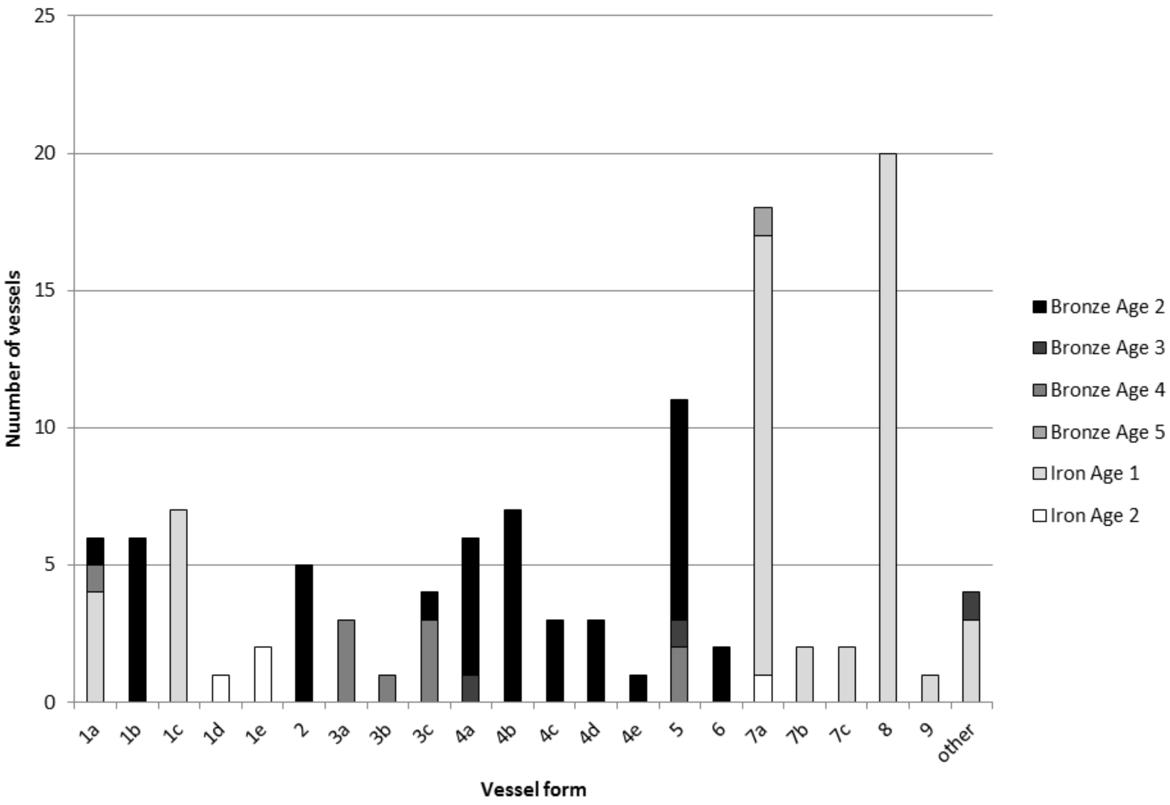

Figure 2. The number of ceramic vessels in each vessel form group according to cultural phase. This graph presents the data for all 123 sampled ceramic vessels.

Mineral inclusions

The other non-plastic inclusions in the fabrics were identified as minerals. Quartz was the most common, but almandine, haematite and rutile were also frequently identified. Other clay minerals (hydrous aluminium phyllosilicates) that could not be identified were present, alongside kaolinite and illite. Smaller quantities of alkali feldspar, apatite, calcium oxide, chromite, gypsum and mica group minerals were identified (Figure 5). There was no difference in the proportions of the identified non-plastic inclusions between the Bronze Age and Iron Age vessels.

Clay matrix groups

The clay matrices of the ceramic fabrics were characterised chemically. The PCA of the clay matrix data indicated that the first principal component displayed the greatest variability between phosphorus and manganese oxides. The second component, with the second greatest level of variability, included phosphorus, titanium and manganese oxides. The third greatest level of variability was observed in sodium and iron oxides (Table 3).

One cluster was identified for the studied assemblage when the PCA values were plotted (Figures 6 and 7). This suggests that the studied ceramics shared a similar chemical composition throughout the sequence, indicating they were made locally from a few nearby sources. The only evidence of imported wares was one vessel from Bronze Age 2, which was different in chemical composition from all other studied ceramics and most likely made from a distant clay source.

No substantial variation in the chemical composition of clay from 'local' wares was evident, regardless of temporal phase. The clay matrix data were less centrally clustered within the Iron Age samples, suggesting greater variation in clay selection for Iron Age pottery making than with the Bronze Age samples, which tended to cluster closer together (Figures 6 and 7). However, similar vessel forms did not necessarily cluster together, and there was no confirmed relationship between vessel form and clay matrix composition.

DISCUSSION: A CHARACTERIZATION OF BAN NON WAT CERAMICS FROM THE BRONZE TO IRON AGE

The earliest change in ceramic technology was the appearance of fibre temper in Bronze Age 4; this was followed by stylistic changes in Bronze Age 5, when new vessel forms—

	Bronze Age 2	Bronze Age 3	Bronze Age 4	Bronze Age 5	Iron Age 1	Iron Age 2
1a Simple unrestricted vessel						
1b Simple unrestricted vessel with pedestal						
1c Simple unrestricted vessel with lip and ridge						
1d Simple unrestricted vessel with inverted rim and pedestal						
1e Phimai Black simple unrestricted vessel						
2 Restricted vessel with everted rim, oval body and cord-marking						
3a Restricted vessel with everted rim, oval body and carination						
3b Restricted vessel with everted rim, oval body, carination, cordmarking						
3c Restricted vessel with everted rim, oval body, carination, and pedestal						
4a Restricted vessel with large everted rim and oval body						
4b Restricted vessel with large everted rim, oval body and cord-marking						

Table 2a. The vessel form groups identified in the studied assemblage. Images are not to scale.

	Bronze Age 2	Bronze Age 3	Bronze Age 4	Bronze Age 5	Iron Age 1	Iron Age 2
4c Restricted vessel with large everted rim, oval body and pedesal						
4e Restricted vessel with large everted rim, oval body, cord-marking, and pedestal						
4d Restricted vessel with large everted rim, oval body, lugs, and pedestal						
5 Small restricted vessel with everted rim						
6 Restricted vessel with everted rim, oval body and flat base						
7a Restricted vessel with everted rim, round body and cord-marking						
7b Restricted vessel, everted rim, round body, carination, and cord-marking						
7c Restricted vessel with large everted rim, round body, carination, and cord-marking						
8 Restricted vessel with everted rim, flat lip, vertical neck, round body, and cord-marking						
9 Restricted egg-shaped burial vessel						

Table 2b. The vessel form groups identified in the studied assemblage, continued. Images are not to scale.

later associated with the Iron Age—began to appear. Variability in clay composition then increased in Iron Age 1. It is apparent that fabric and morphological changes occurred at different times in the Ban Non Wat mortuary sequence. This suggests a gradual development of the Iron Age ceramic tradition, rather than a rapid transition in methods from the Bronze to Iron Age.

Successive stages in the ceramic sequence from the Bronze to Iron ages are as follows:

- Bronze Age 2 ceramics were characterised by: restricted vessels with large everted rims that were highly burnished (forms 3 and 4); restricted vessels with medium everted rims and oval bodies (form 2); small cord-marked restricted vessels (form 5); and unrestricted vessels, some of which had pedestals (form 1). Tempers were commonly untempered, quartz sand, or grog. All vessels were made from local clays, except for one from form group 2.
- Bronze Age 3 ceramics were characterised by large everted rims that were highly burnished (form 4) and small cord-marked restricted vessels (form 5). Vessels were commonly untempered, quartz sand, or grog. All were made from local clays.
- Bronze Age 4 ceramics were characterised by restricted vessels with medium everted rims and oval carinated bodies, some with pedestals (form 3), and small restricted vessels (form 5). A new tempering technique using fibre became dominant at this time, although some vessels continued to be made with non-fibre tempers. All vessels were made from local clays.
- Bronze Age 5 ceramics were characterised by a new set of vessel forms, including large restricted vessels with everted rims and round, cord-marked bodies (form 7). The studied vessels were fibre tempered in the thin body, and quartz sand or untempered in the thicker rim portion. All were made from local clays.
- Iron Age 1 ceramics continued the shapes and forms introduced in Bronze Age 4, including large restricted vessels with everted rims and round, cord-marked bodies (form 7), unrestricted vessels (form 1), and restricted vessels with vertical necks and round, cord-marked bodies (form 8). These vessels were commonly fibre tempered. As with Bronze Age 5, some vessels were tempered with fibre in their thin bodies, and quartz sand or untempered in the thicker rim portions. They were made from local clays.
- Iron Age 2 ceramics continued directly from Iron Age 1 with the addition of Phimai Black wares, including unrestricted vessels (form 1e). These vessels were commonly fibre tempered and made from local clays.

The tempering choice of fibre for the manufacture of pre-existing forms during Bronze Age 4 indicates that this 'Iron Age' tempering method was in use before 'Iron Age' vessel forms were produced. Fibre temper accounted for 50 percent of the sample from Bronze Age 4 burial contexts; by Iron Age 1, it accounted for 88 percent. Bronze Age 4 was thus a time of technological change (in temper) that was followed by morphological changes (in vessel forms) in Bronze Age 5. These phases established the ceramic technology that would be employed by the later Iron Age potters.

The final change in ceramic technology was in clay selection. This study did not produce any strong evidence for the use of both local and non-local clay sources for ceramic manufacture. Most of the clay matrix data suggested that the ceramics were made from a single, reasonably uniform clay composition. Such uniformity was particularly evident amongst the ceramics within the Bronze Age burials. During the early Iron Age, clay selection diversified and variability in clay composition increased, suggesting that more than a few local and similar clay sources were exploited for ceramic manufacture. However, this study does not confirm contact with any other pottery making area at this time. It is possible that local potters at this time selected certain clays for ceramic manufacture, and that less attention was given to just the closest source. Clay requirements are likely to have increased with growth in production, specialisation and population size during the Iron Age. A degree of standardisation in the manufacture of mortuary vessels is evident in vessel forms and temper choice during the Iron Age, but not in clay selection.

Sourcing is a difficult prospect for Khorat Plateau clays. Haematite and rutile occur naturally on the Khorat Plateau: the former in laterite and the latter within quartz grains (Kheoruenromne 1987:324; Kinnunen 1990:183; Pendelton 1941). Previous clay characterisations for the Khorat Plateau have suggested that the clay sources were quartz-rich kaolinites with minor amounts of clay and micaceous minerals (Voelker 2002:44-45). Voelker (2002:45) concluded that local clays were indistinguishable within the Northeast Thailand landscape, and Vincent (1988:225) reported similar problems with distinguishing clay sources and specific ceramic production areas on the Khorat Plateau, due to the indistinct nature of the local country rock. Trace element studies of naturally-occurring clays could enable further source and production centre identification (Vincent 1988:225-226).

There was no apparent link between vessel form and temper and clay selections. The vessel form, temper and clay selection changes identified in this study are connected to the transitional phase between the Bronze and Iron ages. The technological modifications are a reflection of temporal change. This was exhibited by the presence of both early Bronze Age (non-fibre) and Iron Age (fibre) tempering methods in vessel form 3 examples of Bronze Age 4.

The thinner Iron Age vessel forms appear to have developed with the adoption of fibre temper, as the earlier untem-

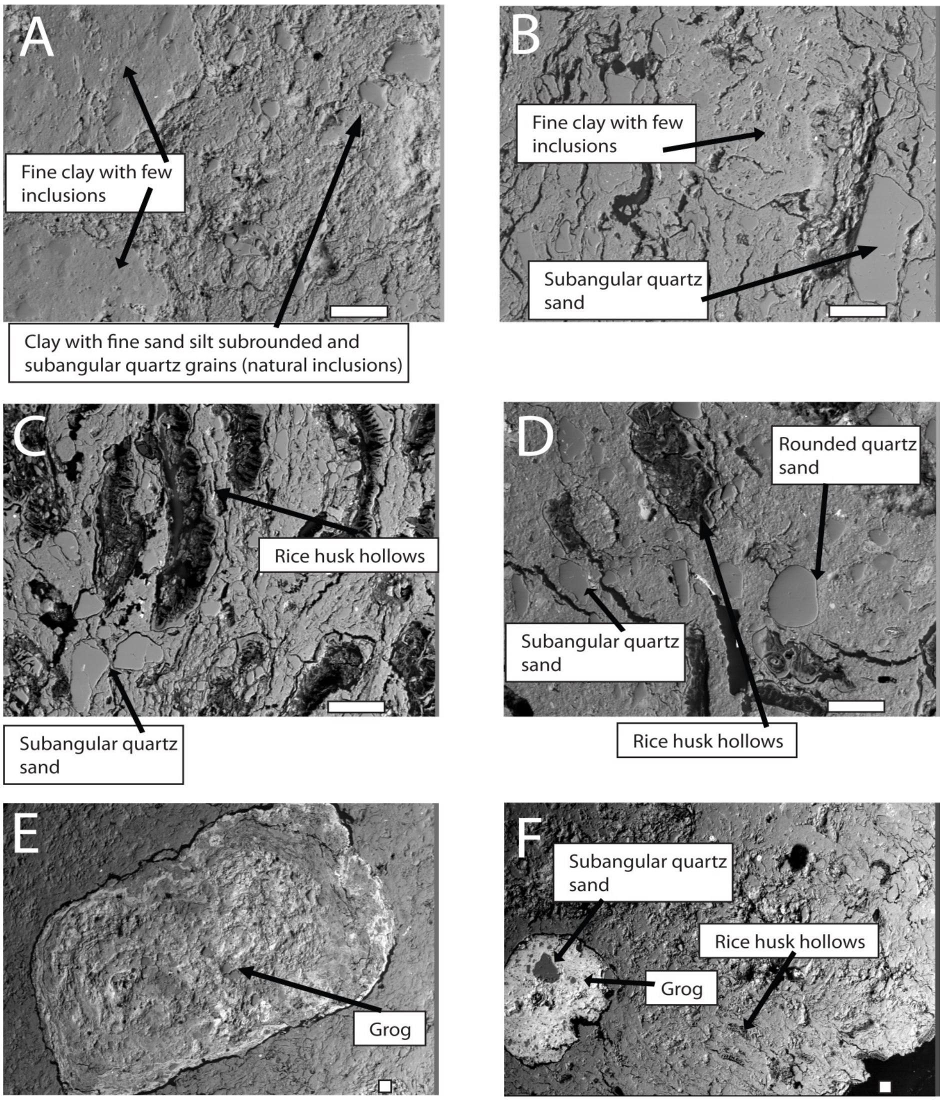

Figure 3a. The first four identified temper groups:

A. *Temper group one: untempered. Body sherd from pot cat. 26515, burial 543, Bronze Age 2. Fabric appears untempered although two clays are mixed in this vessel since a smooth clay and a relatively coarser clay with naturally occurring quartz grains are evident. These two clays do not suggest combining two different sources but more likely a coarse and fine clay within a single source. Magnification x160. Imaging at 15.0keV. Scale 100µm.*

B. *Temper group two: quartz sand. Body sherd from pot cat. 23254, burial 557, Bronze Age 4. Fabric matrix has quartz sand inclusions within smooth clay with few inclusions. Magnification x160. Imaging at 15.0keV. Scale 100µm.*

C. *Temper group three: quartz sand and fibre. Body sherd from pot cat. 24931, burial 404.1, Iron Age 1. Fabric includes fibre hollows and subrounded and subangular fine to very fine quartz sand grains. Magnification x160. Imaging at 15.0keV. Scale 100µm.*

D. *Temper group four: quartz sand, fibre and shell. Body sherd from pot cat. 23019, burial 471, Iron Age 2. Fabric is rice tempered with quartz sand. Shell is not visible in this image. Magnification x160. Imaging at 15.0keV. Scale 100µm.*

E. *Temper group five: quartz sand and grog. Body sherd pot cat. 18815, burial 445, Bronze Age 2. A large grog piece is within the ceramic fabric: the crushed pottery was fired twice in the manufacture of this vessel. Both the grog and clay matrix within the fabric have a similar chemical composition, suggesting they were both made from the same clay source. Magnification x40. Imaging at 15.0keV. Scale 100µm.*

F. *Temper group six: quartz sand, grog and fibre. Rim sherd from pot cat. 25620, burial 478, Iron Age 1. Fabric consists of small fibre particles, grog and quartz sand. Magnification x40. Imaging at 15.0keV. Scale 100µm.*

Element oxide	First principal component	Second principal component	Third principal component
Na_2O	0.02	0.11	**-0.38**
MgO	0.08	0.14	0.09
Al_2O_3	0.06	0.16	0.08
SiO_2	0.05	0.14	0.06
P_2O_5	**-0.71**	-0.38	0.02
SO_3	–	–	–
Cl	–	–	–
K_2O	-0.19	0.03	-0.08
CaO	-0.09	-0.4	0.09
TiO_2	0.08	**0.23**	0.03
V_2O_3	–	–	–
Cr_2O_3	–	–	–
MnO	**0.64**	**-0.51**	-0.01
FeO	0.08	0.12	**0.10**
NiO	–	–	–

Table 3. The first, second and third principal components for each element obtained in PCA with MVARCH (Wright 1991). Note: those elements with infrequent occurrences within the analysed pottery were excluded from the Principal Component Analysis. The bold values indicate the highest and lowest values within each principal component. Therefore, phosphorus and manganese load heavily for the first principal component, phosphorus, titanium and manganese load heavily for the second principal component, and sodium and iron load heavily for the third principal component.

pered and quartz tempered wares were thicker. Even when clay selection diversified in the Iron Age, no single vessel form was associated with a single clay source or an exotic origin. In fact, there was little evidence for any imported ceramics within the studied mortuary assemblage from Ban Non Wat. The presence of clay anvils and burnishing stones in burial contexts throughout the excavated sequence suggests the continuing presence of local potters using local clays.

CERAMIC TECHNOLOGY AND INTER-REGIONAL CONTACT

The appearance of fibre temper in Bronze Age 4 marks an important transition point in ceramic technology at Ban Non Wat. The first use of this technique is dated by Higham and Higham (2009) to around 790 to 740 BC (Table 1). Fibre temper was most likely formed by firing the fibre material in a clay mixture, which was sometimes formed into balls and then crushed and/or sieved before being added as temper to the clay for pottery manufacture (Vincent 1988:88). A similar replacement of earlier methods in favour of fibre tempering has been identified at multiple sites in Thailand (Vincent 1988).

There was most certainly use of fibre temper in some older Neolithic occupations in Southeast Asia, including basal Ban Non Wat and An Sơn in southern Vietnam (pers. obs.; Bellwood et al. ca. 2010). The sites of Khok Phanom Di and Nong Nor on the coast of central Thailand also reveal a use of fibre for tempers before the Bronze Age. Tha Kae in the Lopburi region of central Thailand has revealed thick red slipped and burnished wares, from the earliest and Neolithic layers of the site, that have coarse vegetal fabrics (Rispoli 1992). To the north of Ban Non Wat, sherds tempered with rice have been identified at Ban Chiang during Early Period II, contemporaneous with the aforementioned sites (Vincent 2003; White 2006).

Vincent (1988:186, 218) stated that the Khorat Plateau may have been introduced to fibre temper techniques from an external origin to the south. Beyond the Khorat Plateau, Khok Phanom Di (Figure 1) had pottery of exotic origin throughout its 2000 to 1500 BC sequence. The final phase at Khok Phanom Di, around or after 1500 BC, was entirely industrial and devoted to ceramic production using fibre tempers. Prior to that time, the mortuary ceramics were tempered with grog (Vincent 2004:11-12, 701, 719). Nong Nor Phase 2 in central Thailand, near Khok Phanom Di, also contained fibre-tempered burial ceramics, from 700 - 500 BC (C.F.W. Higham, pers. comm.; Debreceny 1995; Vincent 2004:38-41).

Closer to Ban Non Wat, the Ban Lum Khao assemblage consists of many ceramics whose form and surface decorations parallel those found in Bronze and Iron Age burials at

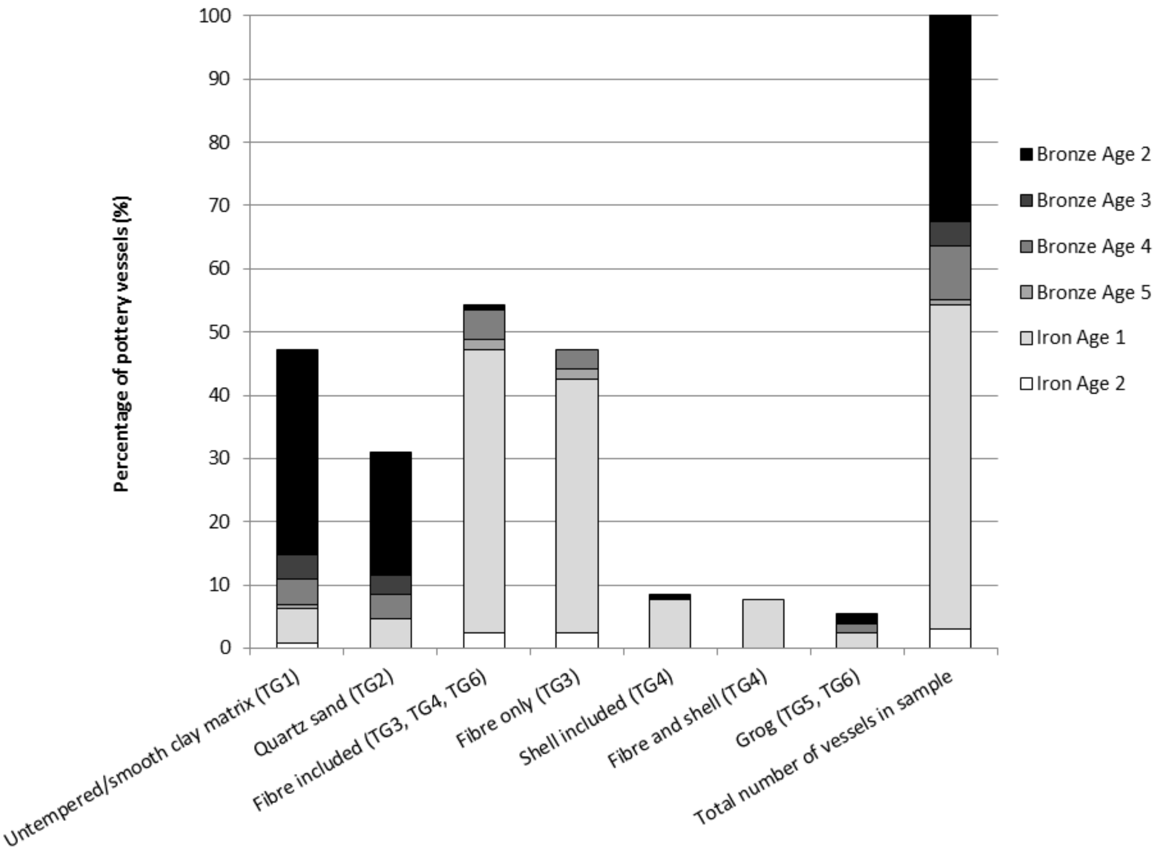

Figure 4. The proportion of temper types according to cultural phase. This graph presents the data for all 123 sampled ceramic vessels. TG is temper group.

Ban Non Wat (O'Reilly 2005). This suggests that the developments in vessel form during the Bronze to Iron Age periods were not isolated to Ban Non Wat; they may be representative of a wider change in ceramic technology on the Khorat Plateau. O'Reilly (2007:585-586) has noted similarities between the ceramics of Iron Age sites on the Khorat Plateau, particularly at Non Muang Kao, Noen U-Loke, Ban Prasat, and now Ban Non Wat. There was not only cultural interaction across this space, marked by the widespread presence of Phimai Black pottery in the Iron Age, but also uniformity in the details of the transition from the Bronze to Iron ages. O'Reilly (2007) identified some early Iron Age vessel forms at Khorat Plateau sites with precursors in Bronze Age assemblages. The evidence from Ban Non Wat supports this claim, since the transition in vessel forms at Bronze Age 5 and in temper at Bronze Age 4 resulted in ceramic types that continued to be placed in Iron Age burials.

The upper Mun Valley sites of Ban Tamyae, Ban Prasat and Ban Suai had sand tempered ceramics in the earlier Tamyae phase (1000 to 600 BC) and fibre tempered ceramics in the Prasat phase (600 to 200 BC), as well as in later Iron Age layers (Vincent 1988:176, 81; Welch and McNeill 1990:113-114). The Noen U-Loke ceramics date almost entirely to the Iron Age, and Voelker (2007:487-493) notes that rice chaff was (almost exclusively) the preferred temper, from AD 200. The lower Mun Valley sites at Roi Et contained ceramics with orthodox grog (a temper made from crushed pottery sherds or fired clay) from 500 to 1 BC, and with fibre from AD 700 to 1000 (Vincent 1988:174-176), so it appears that fibre temper appeared later in the lower Mun Valley than in the upper reaches.

Vincent (1988:101) hypothesised that bleb tempering (the use of crushed, fired balls of clay and rice chaff) in local Khorat Plateau ceramic manufacture began later than 500 BC, as the Iron Age commenced. Vincent (1988:187) once wrote:

> Khorat Plateau ceramic industries may be traced though a series of temper changes which together give an orthodox grog-blebs-fibre sequence. To what extent this system can be generalised awaits future analysis.

The grog-bleb-fibre sequence was not evident within the studied Ban Non Wat ceramic sample. Indeed, Vincent

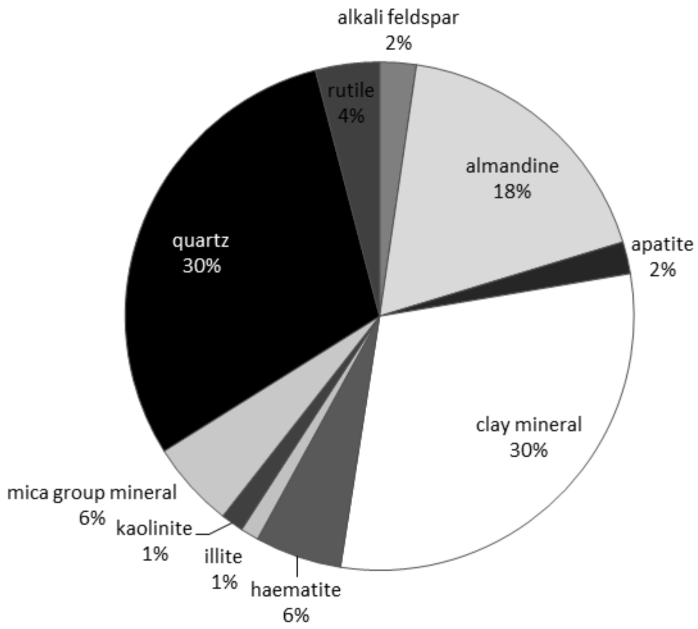

Figure 5. The proportion of non-plastic mineral inclusions in the studied assemblage.

(1988:187) recognised that local variants might have existed. The Ban Non Wat sample contained more fibre than orthodox grog temper. Blebs and/or fibre were used as temper in the later part of the studied sequence at Ban Non Wat, although there was evidence for retention of grog temper into Iron Age 1. At Ban Non Wat, the earliest use of fibre tempering technology in mortuary ceramics can be dated between Bronze Age 3 and 4, between 810 and 780 BC (Higham and Higham 2009). These are the earliest and most reliable dates for local production of fibre tempered ceramics on the Khorat Plateau, and most certainly pre-date the Iron Age.

CERAMIC TECHNOLOGY IN A SOCIAL CONTEXT

Given that fibre tempering has been identified in sherds from Neolithic layers at Ban Non Wat, Tha Kae, Khok Phanom Di and An Sơn, it can be suggested that fibre tempering was originally part of the Neolithic ceramic technology that extended across mainland Southeast Asia. The absence of fibre temper at Ban Non Wat during the subsequent Bronze Age may be explained by three hypotheses:

1. There was a complete loss or rejection of fibre temper by the local potters at this time.
2. The Neolithic people of Ban Non Wat, who also decorated their vessels with red paint and incised and impressed designs (see Wiriyaromp 2007), left the site and were replaced by people—or interacted with people who possessed—knowledge of bronze technology and a different ceramic technology. The appearance of new people and/or traditions is signified by well-adorned, buried individuals who were interred with trochus shell, marble bangles, and shell bead necklaces that coincided with this transition in temper choice. The ornamentation of Bronze Age 2 individuals may indicate that fibre-tempered wares were perceived as inferior for burial contexts. Further fabric analyses of the Ban Non Wat Neolithic ceramics is required, in order to investigate the continuity, or lack thereof, of ceramic technologies from the Neolithic to Bronze Age.
3. Fibre temper was explicitly used for non-mortuary vessels during the early Bronze Age; thus, a comparison of the fabrics of occupation layer ceramics with those from burials is required. The fact that fibre tempered ceramics are not found in association with the well-adorned Bronze Age 2 burials, as stated in hypothesis 2, and the preference for sand tempered vessels in these burials supports a utilitarian function for the fibre tempered vessels manufactured during Bronze Age occupation.

The widespread continuities in ceramic forms and fabrics from the Bronze to Iron ages on the Khorat Plateau suggests there were no significant external population movements or cultural introductions during this time (O'Reilly 2007:585-586). However, the changes in mortuary treatments during the Bronze and Iron Ages are indicative of transformations in trading networks, access to particular resources (stone, metals, clay, shell and marble), knowledge access, inter-village or regional communication, technological developments (agriculture, metallurgy, ceramic and glass manufacture), and specialisations (weaving and ceramic manufacture). It is thought that technological specialisation occurs as

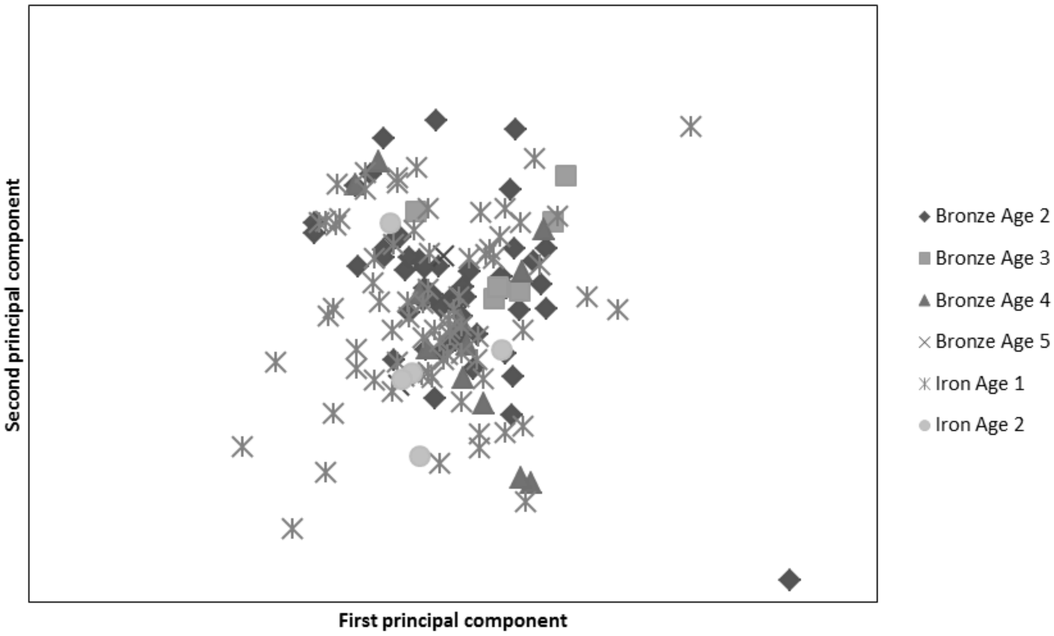

Figure 6. The ceramic vessel clay matrix PCA plot of the first and second principal components.

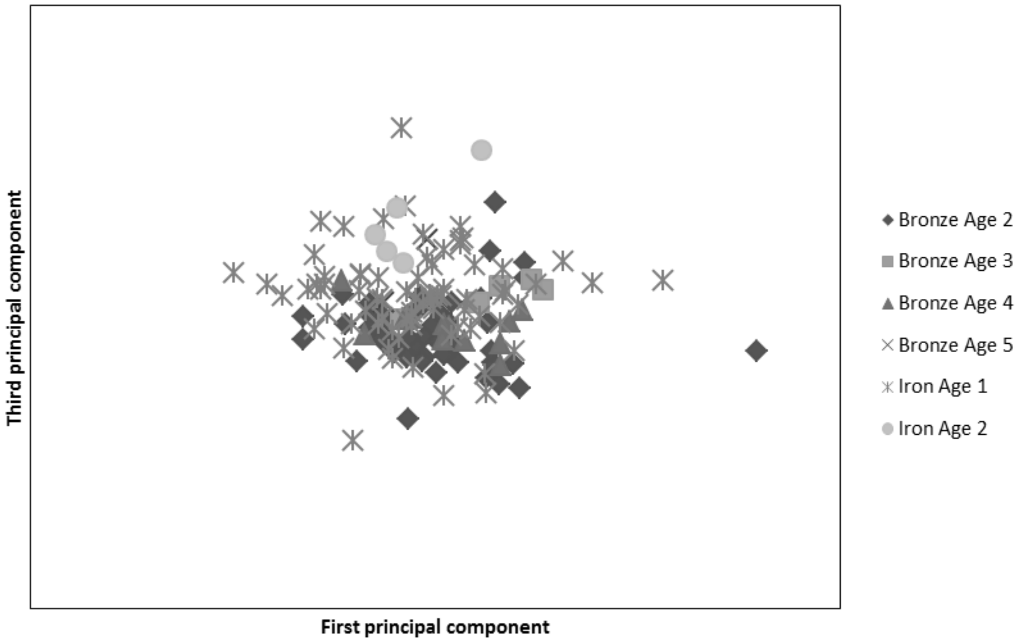

Figure 7. The ceramic vessel clay matrix PCA plot of the first and third principal components.

a result of a “pre-existing sociological power” rather than as a cause for socio-political changes (Roux and Matarasso 1999:66). Craft industry evidence, coupled with occupation-specific mortuary goods, displays the role of individuals in society. The representation of weavers—inferred from the presence of red ochre, grey clay for use as a dye or mordant and spindle whorls in burial contexts—from Bronze Age 5 to the Iron Age at Ban Non Wat supports the hypothesis for occupation-specific burial goods at this time. In contrast, exotic marble and shell items were found in early Bronze Age interments.

As with the local ceramic technology, elements of Iron Age social development were embedded in the Bronze Age. The lack of well-adorned individuals buried from Bronze Age 3 at Ban Non Wat may be indicative of increased warfare, a lack of inter-community trade for exotic marine and marble items, or both (Higham 1996:32-33). Recent research has indicated that these burials represent the instability in lineages that attained social prestige during the Bronze Age (Higham 2011). Exotic mortuary goods were re-introduced once trading increased in the Iron Age. It is apparent that a significant communicative act took place between Bronze Ages 3 and 4, through which knowledge of rice tempering was transferred. Ceramic standardisation and the predominant use of rice temper were in place by Bronze Age 4, and further resource control, such as water with moat systems, would be imposed in the Iron Age (Boyd 2007:29; Boyd and Habberfield-Short 2007:27).

As a result of growing craft industries and exchange, artefact variety within burials increased during the Iron Age. The appearance of agate, carnelian, glass, new bronze ornaments (bells, rings, torcs, belts and spiral earrings), and iron and bimetallic (iron and bronze) objects, such as rings and spears, at Noen U-Loke and Ban Non Wat (Chang 2007; Connelly 2007; Sarjeant 2006) attests to this. The evidence of ceramic technology presented in this paper suggests the possibility of earlier cultural interactions during the Bronze Age as an explanation for the introduction or revival of fibre tempering for mortuary vessel manufacture.

CONCLUSION

This paper presents an analysis of the mortuary ceramic vessels from Bronze and Iron Age burial contexts at Ban Non Wat. Ceramic forms and fabrics were observed to change more than once during the Bronze and Iron ages. Forms, tempers and clay selections were modified during the sequence at different times. Morphologically, a small change was observed in vessel forms between Bronze Age 3 and 4, and a further substantial modification in form was identified between Bronze Age 4 and 5. The forms identified in Bronze Age 5 continued into the Iron Age, and by Iron Age 2 a further addition was made to the ceramic assemblage with the introduction of Phimai Black wares. Another transformation in ceramic manufacture was observed in temper selection. The use of quartz sand, grog and no temper in Bronze Age 2 and 3 was superseded by fibre tempering in Bronze Age 4, although the former tempers were retained in some vessels. This new method of fibre tempering became dominant and persisted into the Iron Age, and continues to be applied by Southeast Asian potters today. A final transition was observed in clay selection. Clay chemical compositions were reasonably uniform throughout the Ban Non Wat sequence, although increased procurement of clay from a wider local area became apparent at the beginning of the Iron Age. Thus, local ceramic production utilised local clay resources, adopted new tempering techniques, and modified vessel forms in a continuous sequence from the Bronze to Iron ages.

Developing from previous research—which suggests that fibre tempering was introduced at the beginning of the Iron Age—the current findings confirm the use of fibre temper on the Khorat Plateau from the mid-Bronze Age. The evidence from Ban Non Wat indicates that this introduction may have been as early as 2800 years ago for mortuary vessel manufacture. Further research on the Neolithic and occupational ceramics at the site, and on the continuity and discontinuity of Neolithic ceramic technologies into the Bronze Age, will reveal more details about the inception and longevity of these ceramic traditions on the Khorat Plateau.

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