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DATING EARLY BRONZE AT BAN CHIANG, THAILAND

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Abstract: In 1982, the dating for the earliest bronze grave good at Ban Chiang, Thailand, was revised from the fourth to the early second millennium B.C. Some scholars did not accept the revised dating, and have argued for a date of younger than 1500 B.C. The debate has focused on bronzes that were grave goods and has not addressed the non-burial metals and metal-related artefacts. This article summarizes the burial and non-burial contexts for early bronzes at Ban Chiang, based on the evidence recovered from excavations at the site in 1974 and 1975. New evidence, including previously unpublished AMS dates, is presented supporting the dating of early metallurgy at the site in the early second millennium B.C. (c. 2000-1700 B.C.). This dating is consistent with a source of bronze technology from outside the region. However, the earliest bronze is too old to have originated from the Shang dynasty, as some archaeologists have claimed. The confirmed dating of the earliest bronze at Ban Chiang facilitates more precise debate on the relationship between inter-regional interaction in the third and second millennia in Asia and the appearance of early metallurgy.

Keywords: Ban Chiang, Bronze Age, Dating.

Introduction

The dating[1] of the earliest bronze metallurgy at Ban Chiang and in Thailand is of great interest to archaeologists working in Southeast and other parts of Asia, as well as to scholars of ancient metallurgy generally (Chernykh 1992: 2; Craddock 1995: 135; Mair 1998: 21; Muhly 1981, 1988: 16; Tylecote 1992: 15; Wertime 1973). Widespread interest in the dating of the appearance of bronze at this one site in northeast Thailand stems from the fact that the Ban Chiang evidence has been an important component in debates about the nature and sources of metal technological invention, innovation, and transmission in the Old World as a whole (*e.g.*, Higham 1996a: 9-11). Arguments at both the continental level (*e.g.*, that metals spread from west to east, south to north, the reverse of either, or were discovered in complete isolation multiple times) and at the regional level (*e.g.*, that specific cultures were in contact during prehistoric times) depend on accurate and precise dating of archaeological evidence. Since, at the current level of knowledge of Asian archaeology, shifts of two hundred years can affect interpretation of continent-wide cultural processes, details of the dating evidence are not trivial, but rather fundamental to the discussions.

As Southeast Asian archaeology is still at an early stage of development, data from single sites often provide much of the evidence for a region's chronology. The thinness of the evidence supporting regional sequences, along with the difficulty of interpreting radiocarbon evidence from many Southeast Asian mortuary sites, not uncommonly results in variant interpretations of individual site sequences[2]. Differing interpretations of the dating evidence of the earliest bronze at the site of Ban Chiang have been instrumental to significant debates in world archaeology including whether Southeast Asia was a source of metallurgy for other parts of the Old World (*e.g.*, Rainey 1992: 238) or a recipient of metallurgy from the Shang dynasty in China (*e.g.*, Higham 1996a). Therefore, new details concerning the evidence for the earliest metals at the site merit particular attention.

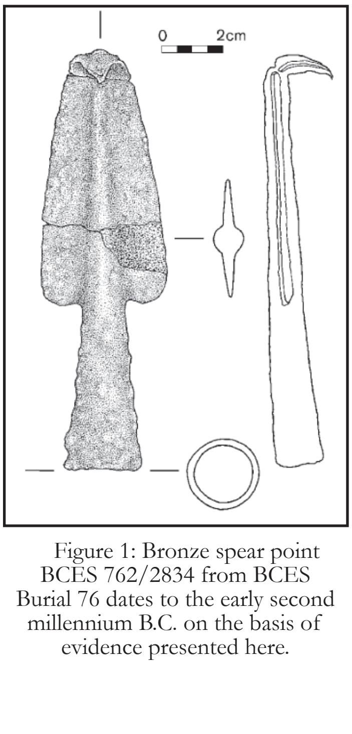

Figure 1: Bronze spear point BCES 762/2834 from BCES Burial 76 dates to the early second millennium B.C. on the basis of evidence presented here.

Background to the current debate

The first dating for bronze from Ban Chiang was published in a preliminary publication from the joint University of Pennsylvania Museum/Fine Arts Department of Thailand excavations at Ban Chiang in 1974 and 1975 (Gorman and Charoenwongsa 1976). Based on a quick and partial assessment of stratigraphic and radiocarbon evidence, the lowest bronze grave goods, consisting of bangles and a bent tip spear point (Fig. 1), were placed in the time range of c. 3600-2900 B.C. Since this dating implied that the tin-bronze in prehistoric Thailand was older than that of Mesopotamia and western Asia generally (Muhly 1981: 137), a long-standing vision of world prehistory that presumed that Mesopotamia was the source of bronze metallurgy, urban societies, and other human advances toward civilization for other parts of the world was called into question (Muhly 1976). It was thought at that time that the early bronze in Thailand might reveal a place of independent invention of metallurgy, or even the source for Mesopotamian bronze metallurgy. Debate ensued (see summary in Muhly 1981).

White (1982: 77) revised the dating of the appearance of bronze at Ban Chiang to the early second millennium B.C. Specifically, the bent tip spear point from Burial Phase III was dated to c. 2000 B.C. at the earliest. White (1986: 285-289, 320) explained further that even if one placed the bent tip spear point more generally in the first half of the second millennium B.C., considering its technical sophistication, and other metal-related and chronological data[3] suggesting that metal appeared at the site earlier than that particular spear point, "2000 B.C. is not an unreasonable estimate for the appearance of bronze in the region" (White 1986: 289). A date in the vicinity of 2000 B.C. for the appearance of bronze in Thailand has since been used by many regional scholars (*e.g.*, Bacus 2006; Bayard 1996-1997; Glover, Syme 1993; Higham 1988a: 138 [but *cf.* Higham 1988a: 153], 1989; Pigott 1998; Spriggs 1996-1997).

Debate over the dating for the earliest bronze at Ban Chiang has continued, although based on revised premises. White (1988a: 179) argued that bronze metallurgy appearing as a fully developed, regionally distinctive technology in northeast Thailand by the early second millennium B.C., with no evidence for experimental stages of development, was consistent with a source external to the region. White argued that the appearance of bronze c. 2000 B.C. was too late a date to imply independent invention of copper-base metallurgy within the region, given the advanced configuration of the bronze technology occurring in a time frame when bronze was appearing in many places in central and eastern Asia (see Chernykh 1992: 2; Linduff 2000, 2004; Mair 1998: 21; Mei 2000, 2003).

The same evidence (developed bronze metallurgy in northeast Thailand c. 2000 B.C.) also discounted an argument that the Shang dynasty, China was the source of the earliest prehistoric bronze at Ban Chiang (White 1988a; contra Higham 1996a: 5, 338). The Shang dynasty, which is traditionally dated as beginning c. 1600 B.C.[4], was too young to be the source for the earliest bronze in Thailand. Shang metalworkers moreover employed very different smelting and casting technologies and emphasized a distinctive typological range in comparison with Southeast Asian early bronzes[5]. Instead, White has noted similarities in typological and technological range between early metals of Thailand and those of the central Asian interior (White 2000)[6]. White further has suggested that "the early Thai evidence for a developed bronze technology lacking experimental stages may be related to a rapid and broad spread of bronze technology in Asia east of the Urals dating from about 2000 B.C." (White 1997: 104).

White's assessment of the significance of a c. 2000 B.C. dating for the earliest bronzes at Ban Chiang differs from that of Charles Higham. Higham has stated (*e.g.*, 1996a: 312; see also Higham 2002: 134; Higham, Thosarat 1998: 217) that, in his view, dating the earliest bronze to c. 2000 B.C. at Ban Chiang would support an argument for independent invention of metallurgy in Thailand or Southeast Asia, contra White's assessment. However, Higham's preferred interpretation of the dating evidence at Ban Chiang is that the earliest bronze at Ban Chiang, and elsewhere in Southeast Asia, dates to 1500 B.C. or younger (1984, 1988a, 1996a, 2002: 113, 166). His dating comfortably fits his view that the source of the technology can be traced to the Shang dynasty (Higham 1996a: 33, 2002: 27, 353, 2004: 52, 2006: 19).

There are many issues at stake in addition to dating that are pertinent to the overall discussion, such as technological differences between Southeast Asian and Shang metal production, metal ore sources in Thailand and elsewhere in Asia, social contexts for metal technology transmission, and inter-regional cultural relationships across Asia during the second and third millennia B.C. Nevertheless, for the purposes of this article, these are subsidiary issues to the accurate dating for the earliest bronze in Thailand, and particularly at Ban Chiang, as correct chronology is the basis for any discussion of intra-regional technological development and inter-regional technological relationships.

This article presents new evidence in support of the interpretation that bronze metallurgy appeared at Ban Chiang (and by implication northern northeast Thailand) by the early second millennium B.C. Only full publication in monographs under preparation of all the details for Ban Chiang's chronology, stratigraphy, and materials data will provide all pertinent evidence for the dating of Ban Chiang metals. However, several AMS dates with key stratigraphic positions are available that succinctly clarify the dating of the earliest metals. This article publishes for the first time two AMS dates that became available after a set of Early Period AMS dates were published in White (1997). Interpretation of the new AMS results in combination with five AMS dates previously published in White (1997) provides coherent dating of the early metals at Ban Chiang.

Where and what are the early metals at Ban Chiang?

Prior to discussing the dating of the early metals at Ban Chiang, what constitutes the evidence for the "early" metallurgy at the site needs definition. The Ban Chiang Early, Middle, and Late Periods (abbreviated as EP, MP, and LP respectively) were originally defined by White (1982) primarily on the basis of changes in grave ritual, supported by evidence from ceramics and soil stratigraphy. For the purposes of this discussion, "early" metal-related evidence are metals and metal-related artefacts (crucibles, slag) in the "lower" part of the Ban Chiang Early Period.

The Early Period at Ban Chiang has been subdivided into a lower Early Period and an upper Early Period at the transition between Burial Phase IV and Burial Phase V (Table 1). The division between Phase IV and Phase V is based on changes in grave orientations coupled with a change in ceramic styles[7].

Period		Burial Phase	Working date range
Late Period (LP)		X	c. 300 B.C.–A.D. 200
		IX	
Middle Period (MP)		VIII	c. 900-300 B.C.
		VII	
		VI	
Early Period (EP)	upper	V	c. 1700-900 B.C.
	lower	IV	c. 2100-1700 B.C.
		III	
		II	
		I	
Initial Period (occupation prior to Burial Phase I)			?- c. 2100 B.C.

Table 1. Chronology of Ban Chiang Periods.

It is important to note that although much of the discussion of the Ban Chiang evidence and chronology has focused on mortuary remains, the deposit surrounding the human burials demonstrates that the site was occupied throughout the burial sequence, and much of the site's depositional buildup was from activities of daily life. Although the excavators were not always able to identify grave cuts of burials, the depths from which graves were cut (i.e., stratigraphic sources of graves, or grave sources for short) can still be estimated by considering details of inter-cutting and superposition of burial and occupation features, and other stratified cultural and soil evidence[8]. The combination of grave sources, soil changes, and cultural stratigraphy enables the deposit from outside of burials to be assigned to lower and upper Early Periods, as well as the Middle and Late Periods.

There is another aspect of mortuary deposition in some portions of the site that helps chronological interpretation, namely groupings of superimposed graves. At the locale at Ban Chiang excavated in 1975, termed the "BCES locale," the lower Early Period burials occur in three discrete rows, and within each row burials from Phases II through IV superimposed each other. (No definite Early Period Phase I burials were excavated from the BCES locale.) The burials from the upper Early Period (i.e., Phase V) at BCES not only differ in orientation from the lower Early Period rows of burials, the Phase V burials were more spread out and did not show marked clustering within the confines of the excavated area. At the locale excavated in 1974, termed the "BC locale," distributions for both upper and lower Early Period burials were less overtly or tightly clustered, contrasting with the distinct and aligned sets of superimposed lower Early Period burials at BCES. The sequences of superimposed burials in clearly defined rows in the lower Early Period at the BCES locale therefore provide particularly clear evidence for the position of associated metals within the cultural sequence, as well as provide additional controls on the relative sequence of grave-associated dates.

Ban Chiang is a mixed-usage mortuary and occupation site, and metals were recovered from both contexts. As the evidence of early metallurgy at Ban Chiang is here defined as metal from the lower Early Period, these artefacts include any metal grave goods in Burial Phases I-IV, and metals and metal-related materials in contemporaneous non-burial (i.e., non-grave good) deposits. Non-burial deposition at Ban Chiang has usually been down-played in previous discussions of the site, in part because it has been more straightforward to discuss the cultural sequence of Ban Chiang (and most other metal age sites in Thailand) on the basis of the relatively intact artefacts that come from burials. Yet depositional contexts outside of burials reveal abundant evidence of habitation and occupation activities (post holes, pits, refuse scatters, etc.). In fact the majority of metals and metal-related remains recovered from Ban Chiang were not grave goods.

It should also be noted that occupation of Ban Chiang may have preceded the beginning of mortuary deposition, at least the portions of the mortuary sequence uncovered in the 1974 and 1975 excavations. This possibility is suggested by the fourth millennium B.C. dates from basal portions of the site, in concert with evidence for possibly anthropogenic, intensive disturbance of the environment in the Ban Chiang region in the period of roughly 4400-1800 B.C. (White 1997; White *et al.* 2003: 123; see also discussion in White 1986: 222-223). Occupation evidence prior to EP Burial Phase I (termed the Initial Period in Table 1) appears to be pre-metal, hence needs no further consideration in this paper. Although more evidence of the earliest occupation of Ban Chiang and similar sites is needed (Higham 2002: 91), the important point to be emphasized here is that the site was occupied during all phases of mortuary deposition. Interpretation of the occupation evidence is essential to understanding Ban Chiang and similar sites.

The full analysis of the 403 metal pieces recovered from prehistoric levels at Ban Chiang (including fragments and casting spillage) reveals that only 62 metal artefacts, or 15% of the site's total prehistoric metal assemblage, can be classified as grave goods, i.e., metal artefacts whose position in a grave indicates deliberate interment with a skeleton (such as bangles on wrists or ankles). Moreover, metal-related artefacts from Ban Chiang also include 88 crucibles (mostly fragments), 10 pieces of slag, and 4 probable mold fragments, none of which are grave goods. Of the 505 prehistoric artefacts excavated in 1974 and 1975 from Ban Chiang that are metals or objects involved in metal-processing activities, only 12% are grave goods. Eighty-eight percent of all metal-related artefacts excavated from Ban Chiang are not grave goods.

Grave good metal artefacts recovered from the lower Early Period at Ban Chiang total six artefacts from two BCES burials. Five bronze bangles were recovered with BCES Burial 38 (Phase IVc), and one socketed bronze spear point with a bent tip (Fig. 1) was recovered from BCES Burial 76 (Phase IIIa).

Artifact class	Grave good	General soil matrix	Feature	Totals
Bangle	5[a]			5
Point	1[a]			1
Wires/rods		1[a]	1[b]	2
Flat		2	2[c]	4
Amorphous		5[d]	4[e]	9
Crucible fragments			4[f]	4
Slag		1[g]		1
Totals	**6**	**9**	**11**	**26**

Table 2. Contexts for metal and metal-related artefacts from the lower Early Period at Ban Chiang.

Note: the ten metal and metal-related artefacts from the BCES locale are indicated in the footnotes. The sixteen other artefacts are from the BC locale.
[a] from BCES.
[b] from a pit.
[c] both from probable grave fill, one from BCES.
[d] one from BCES.
[e] features include hearth (1), pit (1), and probable grave fill (2).
[f] features include grave fill (2), pit (1, from BCES), interred pot (1).
[g] removed from section.

Non-burial metals from the lower Early Period

There are twenty metal and metal-related artefacts recovered from lower Early Period deposits that are not grave goods (Table 2), four from the BCES locale and sixteen from the BC locale. The metal and metal-related artefacts that were not grave goods are generally small and fragmentary artefacts. They include six fragments of metal artefacts (wires, rods, flat pieces), and fourteen artefacts that likely resulted from metal processing activities, i.e., amorphous pieces that are probably casting spillings[9], crucible fragments, and one piece of slag.

The contexts for non-grave good metals and metal-related artefacts in the lower Early Period deposits are varied. Nine artefacts came from the general soil matrix and eleven came from some kind of feature. The feature contexts include a hearth (one amorphous was recovered from a feature termed a "hearth-very hard fill" on the square plan), pits (one crucible fragment, one wire/rod, and one amorphous), interred pot (one crucible fragment), and probable grave fill (two amorphous pieces, two crucible fragments, two flat pieces).

Artefacts from the general soil matrix have the least clearly defined taphonomic source. While there is no reason to assume that they are necessarily displaced from their original in situ contexts, without being associated with a specific depositional "event" such as the digging of a hole, they perhaps had a higher likelihood of upward or downward post-depositional movement through the deposit by unidentified non-cultural agents (*e.g.*, bioturbation[10]). However, artefacts from feature contexts produced by discrete events or activities (pits, hearths, and excavations of a grave) may be argued to have retained in situ stratigraphic contexts, even if the cultural activity creating the feature displaced earlier deposits as would the digging of graves.

Artefacts that were close to skeletons but were not grave goods are of special interest for discussions concerning the taphonomy of the early metals at Ban Chiang. The position and condition of these six burial-associated artefacts do not suggest deliberate interment with the body as mortuary furnishings. These non-grave good, but burial-associated artefacts are small and fragmentary (*e.g.*, crucible fragments, amorphous, flat pieces). They were commonly recovered during excavation of burials, such as when grave fill was being removed or the skeleton or its grave goods were being exposed or lifted.

Taphonomic scenarios for how fragments of metal and metal-related artefacts that were not grave goods came to be "burial-associated" can assist in evaluation of their chronological interpretation. One likely possibility is that they were in the deposit into which the body was interred. The fragments may have been re-deposited with the fill material around the body that had been excavated for the grave. Obviously materials including metals derived from the deposit into which the burial was interred would predate the grave (*e.g.*, Higham 1984:231, 1989:12, 126), but by a period of time of unknown significance. If the burial was interred into cultural debris of the same culture period as the burial, metal fragments from the re-interred dirt placed around and over the corpse would have been, from the viewpoint of the archaeological time scale, contemporaneous with the grave. Or if the burial was interred into debris from a much older culture, burial-associated metal fragments could have come from significantly older deposits disinterred when the grave was dug and re-interred with the grave fill, as has been argued for other burial-associated but non-grave good materials (Higham 1984:231, 1989:12, 126). Alternatively and probably least common, some metal fragments recovered from grave fill could have derived from higher cultural layers if they had been transported downward through post-depositional bio-disturbances (root, insect, or animal holes) that did not leave clear stratigraphic evidence. However, all scenarios considered, metal fragments in grave fill appear more likely to be older than or contemporaneous with the interment than younger.

While the six metal artefacts that were indisputable grave goods excavated from lower Early Period burials at Ban Chiang provide extremely important evidence for early metals at the site, the group of twenty metal and metal-related artefacts from non-grave good contexts also provides important evidence for, and insights about, the early metallurgy at Ban Chiang. First of all, even if some of the twenty metal artefacts might have found their way to lower Early Period deposits via bio-disturbances undetected by the excavators, the eleven from cultural features, including the six from contexts of grave fill/close to skeletons, have a high probability of deriving from archaeologically in situ contexts[11].

Secondly, nearly three-fourths (14/20, see Table 2) of the metal and metal-related artefacts in the lower Early Period from non-grave good contexts are artefacts from metal-processing (amorphous, crucibles, and slag, more likely from refining and melting activities than from smelting). This evidence indicates that metal processing occurred on site during the lower Early Period. Metal artefacts were not merely traded in from some external source (be it another site or another region). Aside from the grave goods and production-related artefacts, the five non-grave good metals from the lower Early Period that could be artifact fragments (wires/rods and flat pieces), while not abundant, do suggest that metal was used in daily activities. Metal was not reserved for use only as a prestige good or valuable in burial rituals.

All in all, the twenty-six metal and metal-related artefacts from mortuary and non-mortuary contexts in the lower Early Period provide robust evidence for the presence of metallurgy at Ban Chiang within that period.

Dating the lower Early Period at Ban Chiang

Having provided clear evidence for the presence of copper-base metals from burial and occupation contexts in the lower Early Period, the next question to be addressed is the age of those metals. There is an extensive literature discussing White's (1982, 1986) dating of the Ban Chiang cultural sequence based on the ^{14}C determinations from charcoal processed during the 1970s, and this lengthy topic will not be reviewed here (see Higham 1984, 1988b, 1989: 126-129; 1996a: 9-12, 245-246; 1996-97; Higham, Thosarat 1998: 84; Hurst, Lawn 1984; White 1986, 1988b, 1990). Rather the purpose of this discussion is to review the implications of two previously unpublished AMS ^{14}C determinations from lower Early Period Ban Chiang in light of five Early Period AMS determinations already published in White (1997:106, fig. 1). All seven ^{14}C determinations are from rice organics from burial pottery and were processed during a program to refine the Ban Chiang chronology with an AMS dating project undertaken in the 1990s. All ^{14}C determinations on charcoal processed during the 1970s and on burial-associated rice organics processed during the 1990s[12] will be reviewed in relation to the full site sequence in a monograph in preparation dealing with the Ban Chiang excavations, stratigraphy, and chronology. However, the dating for the basal portion of the deposition from which the lower Early Period metals were excavated can be clarified here by considering the seven AMS determinations discussed below.

Issues of dating burials

The thirty-three charcoal dates from Ban Chiang processed in the 1970s will not be discussed here. However, it is important to point out one key issue of the debate concerning those dates, namely the ambiguous taphonomic relationship between some of the charcoal providing ^{14}C determinations and the burials with which the dated charcoal was associated (Higham 1984: 231, 1988b, 1989: 125, 126, 1996a:12). Many of the charcoal samples dated from Ban Chiang were excavated in close association with skeletons (Higham 1988b: 75; White 1986: 142, 1988b: 57). As noted above for metal fragments excavated close to skeletons, an argument has been made that the burial-associated charcoal was re-deposited and significantly predated the interments (Higham 1984: 231; 1989: 126; 1996a: 12). Higham argued that the mortuary sequence, including grave good metals, could not be accurately dated by burial-associated charcoal dates. Not all archaeologists concurred. Bronson's reaction to the re-deposition critique was (1985: 207), "Many of Higham's fellow archaeologists… feel that his criteria for a valid date are unnecessarily strict… it seems improbable that substantial re-deposition should be a general rule… we should be safe in concluding that the majority of radiocarbon dates derive from samples which reached their final resting place in the soil no more than a few decades after the death of the plant or animal from which the sample came."

Even though most metal and metal-related evidence at Ban Chiang comes from non-burial contexts, dating of the metal grave goods has formed the crux of the earlier chronological discussions on the age of metals at the site. Ultimately both burial and non-burial evidence must be combined for a full picture of the cultural and metallurgical sequence at the site. Even though the possibility for contemporaneity of the charcoal with associated burials has been acknowledged (Higham 1988b:75) and supported with ethnographic evidence (White 1986, 1988b), finding a line of evidence for dating the burial sequence independently from charcoal dates was deemed critical for resolving the debates over the appearance of metals in Ban Chiang grave contexts. To satisfy that "The stratigraphic relationship of the sample to the event being dated must… be demonstrated" (Higham 1984: 231), dating materials of indisputable contemporaneity with interments was advocated (Higham1988b: 77; 1996a: 12; 1996-1997: 880).

In short, direct dating of the skeleton or associated grave goods was the only way to address the critiques. Previous attempts to date apatite and collagen from human bone at the site of Non Nok Tha had not produced satisfactory results (Bayard 1979: 2-23), and thermoluminescence dating of unprovenienced pottery from Ban Chiang had also produced significantly problematic results (see review in White 1986: 281-285). The key to dating a mortuary sequence, archaeologists advocated, were dates from organic deposits from grave goods (Glover 1990:155; Higham 1996-1997:880). In particular, for the past two decades, AMS dates from rice chaff temper in pottery have been argued as providing the solution to the problem of dating Ban Chiang and other sites with complex mortuary sequences (*e.g.*, Higham 1988b:75, 77; 1996a: 191, 240, 246, 311; 1996-1997: 882; 2002:91, 93, 113, 129, 353; 2004: 51-52; Higham, Thosarat 1998: 84; Higham *et al.* 2004: 325).

AMS dating of the Ban Chiang burial sequence.

Programs of AMS dating of rice chaff-tempered pottery have demonstrated that, with adequate stratigraphic controls, and with support where possible from cross-dating, such dates can provide reliable chronometric evidence. The Ban Chiang Project program to AMS date rice-tempered burial ceramics was influenced by the success of several programs of dating rice-tempered pottery from Southeast and East Asian sites. Glover (1990) dated Ban Don Ta Phet on the basis of five dates from rice-tempered ceramics from burials. Bellwood *et al.* (1992) reported AMS dates from ceramics tempered with organics including rice grain and rice husks. Of the five reported dates from four Asian sites, three were consistent with other dating evidence and two were older than expected. Eight out of eleven AMS dates from rice-tempered pottery from Non Nok Tha have been accepted by Higham (1996a: 191, 1996-1997: 882; see also discussion by Bayard 1996-1997: 920; Spriggs 1996-1997: 946) although the taphonomy of some Non Nok Tha samples was less than ideal. Hedges *et al.* (1992), who published the Ban Don Ta Phet and Non Nok Tha rice temper dates, also reported widely cited dates from rice-tempered pottery from Pengtoushan and two other sites in China (*e.g.*, Higham 1996-1997: 882; Yan Wenming 1991). The main mortuary phase at Nong Nor was dated by six ^{14}C dates, five of which were from rice-tempered burial ceramics (Higham, Hogg 1998). These dating programs show that with proper evaluation of the consistency of dates both within a site's stratigraphy and with external evidence (*e.g.*, cross-dating the same ceramic style at other sites), reliable AMS dates from rice-tempered pottery are attainable, although inaccurate outliers may occasionally occur. Therefore even though dating rice temper is not a fool-proof method and has been termed "an experimental procedure" (Thomas, McLauchlan 2006:193), a body of accumulating evidence has supported its utility for dating Southeast Asian sequences[13].

Seven AMS determinations from rice temper from Ban Chiang Early Period burial pots were published in White (1997). As pointed out in that publication, two of the seven determinations were markedly inconsistent with other evidence and will be discussed no further here. The five remaining AMS determinations formed an internally consistent sequence with their relative stratigraphic source (White 1997: 106, fig. 1). Of these five, two came from the upper Early Period and three came from the lower Early Period. In addition to stratigraphic internal coherence of the five determinations, the validity of the sequence was further anchored by the early second millennium B.C. date from Pot A of BC Burial 46 (AA-15578). This large infant burial jar (Fig. 2) has a zone of decoration comprised of incised motifs with impressed infilling made by rocker-stamping a dentate, comb-like instrument. This general style employing impressed and incised decoration (termed "i&i" pottery) has been dated elsewhere in Thailand within the same general time frame and somewhat earlier (Higham 2002: 93; Rispoli 1997). These five determinations, along with the two additional AMS determinations from the lower Early Period newly published here, provide a clear chronology for Ban Chiang's lower Early Period and its metal and metal-related remains (Table 3; Fig. 3).

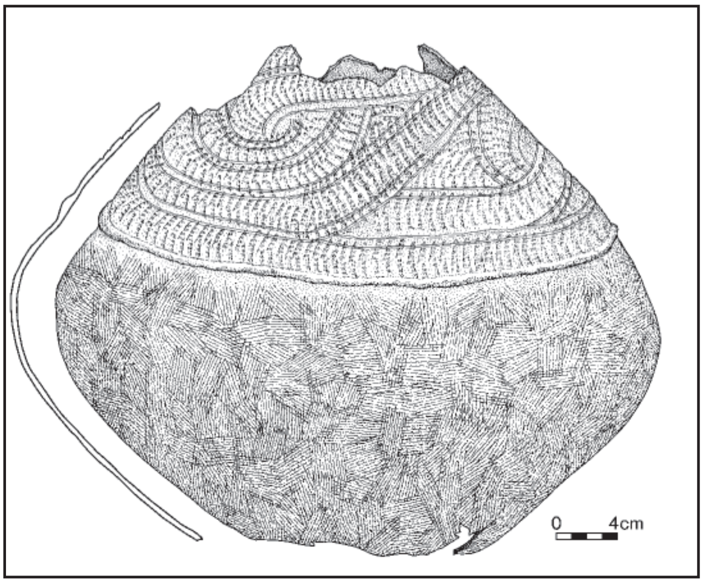

Figure 2: Ban Chiang vessel with incised and impressed (i&i) decoration producing AMS date AA-15578, with a calibrated 2 sigma span of 2032-1526 B.C. Vessel is BC Burial 46 Pot A 1608 from Early Period Phase IIc.

Lab. N°	^{14}C age	$^{13}C/^{12}C$ ratio	Specimen[a]	Burial Phase	Calibration OxCal v4.0.1 IntCal04 curve 95.4%
AA-15581	2970±60	-25.6	BCES B.56 Pot B 2215	EP Vb	1385-1016 B.C.[b]
AA-15582	3320±50	-22.6	BCES B.59 Pot A 2318	EP Va	1739-1496 B.C.[b]
AA-15577	3495±105	-23.32	BCES B.34 Pot A 2018	EP IVc	2132-1533 B.C.[c]
AA-12538	3470±70	NA	BCES B.72 Pot D 2835	EP II/III	1973-1616 B.C.[b]
AA-15578	3465±100	-24.1	BC B.46 Pot A 1608	EP IIc	2032-1526 B.C.[b]
AA-15579	3655±55	-24.4	BC B.47 Pot A 1621	EP IIb	2198-1891 B.C.[b]
CAMS-41264	3730±50	-23.5	BC B.44 Pot A 1339	EP I	2289-1978 B.C.[d]

Table 3. AMS radiocarbon determinations from rice organics in Ban Chiang Early Period ceramics discussed in this article.

[a] CAMS-41264 is on phytoliths from burial pot contents. All other specimens are from rice temper extracted from vessel walls. For more information see White (1997).
[b] ^{14}C determinations previously published in White (1997) with calibrations from 1993 curve.
[c] ^{14}C determination published here for the first time. Pretreatment protocol was the same as that for the dates previously published (see White 1997: 104).
[d] ^{14}C determination on phytoliths published here for the first time. Phytolith carbon extraction protocol followed Piperno (1988) and Mulholland and Prior (1993).

Dating the base of the lower Early Period

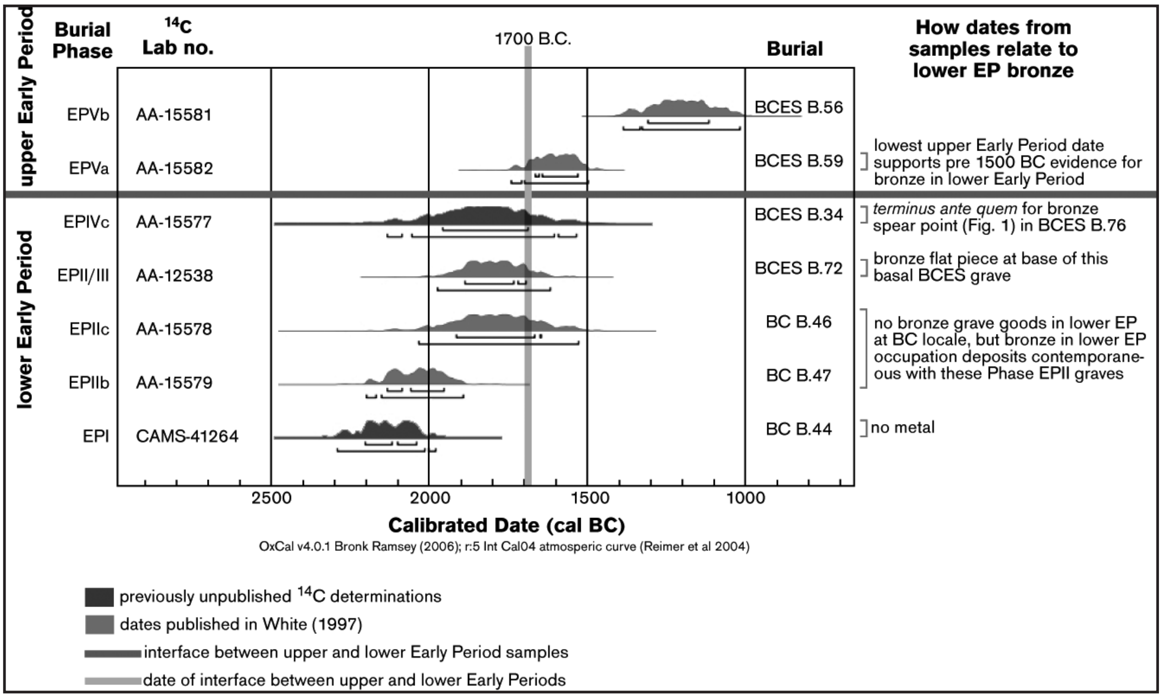

Figure 3: Plot of calibrated AMS dates on rice organics from Ban Chiang Early Period burial pottery.

The first ^{14}C determination newly published here is from the only burial firmly assigned to Ban Chiang's Burial Phase I: BC Burial 44. Hence this determination (CAMS-41264) defines the beginning of Ban Chiang's mortuary deposition, at least for the portion of the site excavated in 1974-1975.

CAMS-41264 is the only determination of the seven discussed here conducted directly on phytoliths. The other six are based on rice temper extracted from pottery vessel walls. As the three BC Burial 44 vessels (White 1982: 59) were not available for rice temper extraction because they have been on display at Ban Chiang Museum in Thailand since 1987, it was necessary to seek an alternative means to attain a ^{14}C determination from Burial Phase I. Soil samples of the contents of burial vessels excavated at Ban Chiang are stored at the University of Pennsylvania Museum. The soil contents of the three pottery vessels lying on the legs of BC Burial 44 were examined, and the materials from BC B.44 Pot A 1339 contained abundant whitish flaky material. When viewed under a microscope by White and MASCA archaeobotanist Naomi Miller (University of Pennsylvania Museum), the flaky material displayed the checkerboard pattern characteristic of rice husks. It was evident that rice had been placed in that vessel presumably as a grave offering. Rice chaff has concentrations of phytoliths, and phytoliths are known to encapsulate organic material from the plant producing the phytoliths (Mulholland and Prior 1993). In the case of an annual seed like rice, the encapsulated organics would be from a very short period of time, and hence be a very desirable material for dating in comparison, for example, with charcoal from wood unidentified to species. In addition, because all the rice grains placed in the vessel as a grave offering were likely harvested within a year or two of each other and the year the deceased died, a date on such material is likely to be relatively precise, with very little possibility for contamination, or the kinds of distortions associated with dates from "old" wood or objects that might have been heirlooms[14].

The phytoliths were extracted from the white flaky material under the supervision of Lisa Kealhofer (then at the Department of Archaeological Research, Colonial Williamsburg), who affirmed the sample had a significant proportion of rice phytoliths. The sample produced a date in the late third millennium B.C. Extrapolation from the 2-sigma span of CAMS-41264, therefore, forms the basis for assigning c. 2100 B.C. to Early Period Phase I and hence to the beginning of the lower Early Period mortuary deposition (as applied in Pietrusewsky, Douglas 2002: 5). Among all ^{14}C dates available from the Ban Chiang 1974-1975 excavations, this "high precision" determination is the highest quality radiocarbon determination with the least possibility of contamination and the closest temporal association of the carbon being dated to the archaeological event. It should also be emphasized, however, that there were no metal grave goods with this burial, no metal fragments were found close to the burial, nor were any metal or metal-related artefacts found in occupation deposits from the area or Level from which the burial likely derived. As far as is currently known, this ^{14}C determination predates the appearance of metal at Ban Chiang, and thus serves as a *terminus post quem* (limit after which) metals were present at the site.

Dating the top of the lower Early Period

The second newly published ^{14}C determination, AA-15577, comes from rice temper of a vessel interred with BCES Burial 34. This flexed burial is assigned to Phase IVc based on its associated ceramics and its relatively high estimated source among BCES Phase IV graves. Burial 34 is cut from the highest stratigraphic position of Phase IV graves at the BCES locale. It is also one of the highest lower Early Period burials at BCES (White 1986: 127). This burial is thus key for defining the end of the lower Early Period mortuary deposition. The 2-sigma span of the calibrated determination from AA-15577 is 2132-1533 B.C. and the 1-sigma span is 1956-1686 B.C. Minimally, therefore, AA-15577 indicates that the higher (i.e., Phase IVc) burials of the lower Early Period were interred within the first half of the second millennium B.C.

Furthermore, AA-15577 serves as a *terminus ante quem* (the date before which) for the lower Early Period graves underlying BCES Burial 34. These underlying graves include BCES Burial 76 with the bronze spear point (Fig. 1). Therefore AA-15577 indicates a minimum age of the first half of the second millennium B.C. for that bronze artifact.

AA-15577 also helps position the temporal interface between the upper and lower Early Periods at Ban Chiang when examined in conjunction with previously published AMS dates from burials in the upper Early Period, especially the lowest BCES Phase V burial (White 1997). This topic will be discussed in the next section.

Integration with other Early Period AMS dating evidence

The two newly presented ^{14}C determinations discussed above integrate well with the set of five internally consistent AMS determinations from Ban Chiang's Early Period published in White (1997). The set of all seven consistent Early Period AMS determinations are listed in Table 3 with their current 2-sigma calibrations. The Oxcal plot of the seven calibrated dates (Fig. 3), which graphically shows 1- and 2-sigma ranges for each date, provides a clearer sense of the likely date ranges of each date relative to the others. Although one determination is from phytoliths and the other six are from rice temper extracted from pottery vessels, the $^{13}C/^{12}C$ ratios are generally compatible with carbon derived from rice, as all but one fall within the range of values recorded from modern rices (-26.2 to -23.4) collected in the Ban Chiang area (King 2006: 128). This set of seven AMS dates helps to define the temporal boundaries for the lower Early Period to approximately 2100-1700 B.C.

Positioning the boundary between the upper and lower Early Periods at approximately 1700 B.C. is based particularly on the temporal relationship between two dates from the BCES locale: AA-15577, from Phase IVc BCES Burial 34 (at the top of the lower Early Period), and AA-15582, from Phase Va BCES Burial 59, the lowest upper Early Period grave. Figure 3 shows the OxCal plot of all seven calibrated AMS dates. An estimate of 1700 B.C. is the most compatible placement for an approximate boundary between Phase IV and Phase V based on those two determinations. Even if future evidence suggests that the boundary between the lower and upper Early Periods should be adjusted, the current evidence indicates that the lower Early Period will nonetheless fall in the first half of the second millennium B.C.

Implications for dating early metal at Ban Chiang

At the most general level, this discussion above shows that metals at Ban Chiang date from the first half of the second millennium B.C., thus supporting previous arguments for pre-1500 B.C. metal at the site and by implication in the region (White 1986, 1997). This evidence also supports metal appearing at the site in the early second millennium B.C., i.e., by c. 1700 B.C. But what does the evidence indicate for the first appearance of metal at the site?

A comprehensive answer to this question requires assessment of all details pertinent to the earliest metal remains, including plans and sections showing where metals were recovered in relation to occupation and mortuary features. These details are planned to appear in forthcoming monographs on metals and chronology at Ban Chiang. Here, however, a succinct overview is provided. Grave good and occupation metal-related evidence from both excavation locales needs to be considered.

Metal was excavated from two of the basal graves at the BCES locale: the bronze spear point in the flexed BCES Burial 76, and a bronze flat piece at the base of BCES Burial 72[15]. These two burials are among the dozen or so lowest BCES graves. As a grave good, the spear head is obviously contemporaneous with the interment of BCES Burial 76. However, as discussed above, the bronze flat piece could predate or be contemporaneous with BCES Burial 72. But given the piece's recovery from the base of the burial, which cut deeply into natural soil (see White 1986: 129), it is unlikely to postdate the interment. BCES Burial 72 from Phase II/III also provided AMS date AA-12538, which has a 2-sigma calibrated span of 1973-1616 B.C. It can be argued therefore that this evidence supports the presence of bronze at the BCES locale during the first half of the second millennium B.C.

However, the BC locale provides evidence for the earliest appearance of metal at Ban Chiang, slightly earlier than the evidence at the BCES locale. Although there were no metal grave goods recovered from lower Early Period burials at the BC locale, sixteen metal and metal-related artefacts were recovered from the BC lower Early Period occupation deposits. Contexts included pits and a hearth at the same depths as Early Period Phase II burials (including all sub-phases, a, b, and c) and grave fill[16] of two Phase IIc burials, as well as the general soil matrix. This evidence indicates that metal was present during Early Period Burial Phase II but in occupation contexts.

Two AMS dates came from Phase II burial vessels from the BC locale. The stratigraphically higher Phase IIc BC Burial 46 Pot A 1608 (Fig. 2) produced AA-15578 with a 2-sigma calibration of 2032-1526 B.C. This infant burial jar was one of the highest Phase II graves at the BC locale. The vessel is also notable for its incised and impressed (i&i) decoration. Similarly decorated vessels in Thailand are considered to date from the same time range and earlier (as early as the late third millennium B.C.; Higham 2002: 93; Rispoli 1997). Therefore the AMS date is consistent with independent dating of the vessel's decorative style.

From Phase IIb BC Burial 47, which underlay BC Burial 46, came AA-15579. Its calibrated date with a 2-sigma span is 2198-1891 B.C. The occupation Level from which EP Phase IIb graves were excavated, including BC Burial 47, produced four copper-base artefacts[17]. An additional copper-base piece was excavated from a hearth in the underlying Level[18]. AA-15579 provides a basis for arguing that copper-base metallurgy at Ban Chiang is present by the early second millennium B.C. Although the 2-sigma span for AA-15579 is the time range within which the date will likely fall, for convenience "c. 2000 B.C." is the date used to refer to the appearance of copper-base metal at the site.

Although the evidence for the presence of metal c. 2000 B.C. and in occupation deposits during Burial Phase II sub-phases is not massive, it is similar to other sites cited as demonstrating an initial appearance of metals in a region (An Zhimin 1998, 2000; Chernykh 1992; Thornton 2002). Initial appearance of metallurgy in regions often consists of small ornaments, implements (*e.g.*, awls), and fragments in both occupation and burial contexts (Thornton 2002: 30-31). For example, copper-base objects in the Longshan culture often consist of a few small copper or bronze items recovered from some but not all sites. The metal is not found in elite Longshan graves and rarely appears in commoner graves (Linduff *et al.* 2000: 339, 340, 344). Given that the exposure of occupation deposits contemporaneous with EP IIa and EPIIb graves at the BC locale was only about 74 m^2, recovery of 5-6 copper-base flat, amorphous, and wire/rod pieces is notable.

Summary and Conclusions

The evidence presented here indicates that bronze technology was present at the site of Ban Chiang prior to 1500 B.C. and probably was present by approximately c. 2000 B.C. This conclusion is built upon several lines of evidence.

First, the presence of bronze during the lower Early Period as grave goods and in occupation contexts is established. Twenty-six copper-base and metal processing artefacts can be attributed to lower Early Period burial and non-burial deposits (Table 2), including six bronze grave goods and 20 metal and metal-processing artefacts from non-grave good contexts.

Second, seven calibrated AMS ^{14}C dates from the Ban Chiang Early Period burial ceramics are reviewed and shown to be internally consistent with their relative stratigraphic contexts. Five dates from lower Early Period burials, supported by a sixth from an early upper Early Period burial, demonstrate that lower Early Period burials were interred from the late third millennium B.C. into the first half of the second millennium B.C. These dates support assignment of a span of c. 2100-1700 B.C. for the Ban Chiang lower Early Period.

Third, the earliest burial phase, Early Period Phase I, shows no evidence for the presence of metal. Thus the appearance of metal appears to postdate the beginning of the Ban Chiang mortuary sequence, at least the portion of the mortuary sequence excavated in 1974 and 1975. However, occupation contexts surrounding Early Period Phase II burials do contain metal. A date of approximately c. 2000 B.C. is suggested for this earliest appearance of metal, based on the calibrated date of AA-15579.

Fourth, the association of bronze in occupation contexts contemporaneous with Early Period Phase II burials supports dating bronze to the first half of the second millennium B.C. independently of the AMS dating presented here. Many Phase II burials have the i&i pottery which on the Khorat Plateau and in Thailand generally is considered to date within the range of c. 2300-1500 B.C. (Higham 2002: 93; Rispoli 1997). Elsewhere, this pottery has been considered to be pre-metal and indicative of the spread of neolithic rice agriculturalists into Southeast Asia from the late third millennium B.C. (Higham 1996b, 2002: 352, 2004, 2006: 17; Higham, Thosarat 2006: 100). The Ban Chiang evidence indicates that this pottery style, at least in some phases of use at some sites, is contemporaneous with copper-base metallurgy.

Finally the evidence presented here is a summary of much more detailed stratigraphic, cultural, and absolute dating evidence that is planned to be published in forthcoming monographs from the site. The monograph on the Ban Chiang chronology will show that the AMS dates from rice temper are compatible with the charcoal dates from the site. The two independent lines of dating evidence support and complement each other, and provide a comprehensive basis for interpreting the chronology of Ban Chiang's mortuary and occupation deposits. The most critical elements of the evidence for dating the initial presence of metal at Ban Chiang by the early second millennium B.C., however, are stated here.

The evidence presented here for c. 2000 B.C. copper-base metallurgy in northern northeast Thailand should stimulate careful examination of sites elsewhere in Thailand and mainland Southeast Asia with deposits dating in the early second millennium B.C. for evidence of metallurgy. Sites with significant exposures of deposits of this time frame are still rare in Thailand (Higham 2002: 93). For those that have been excavated, analyses have focused on mortuary rather than occupation deposits. Moreover, even within the period of time when bronze technology is broadly accepted to be present in Thailand, marked site-to-site variability in the occurrence of bronze remains has been noted. No bronze grave goods were recovered from the bronze age site of Ban Lum Kao, for example, although bronze artifact production evidence was found in non-burial contexts (Higham 2002: 142). Nonetheless, in central Thailand, the bronze bar in burial 6ii at Ban Mai Chaimongkol, while not directly dated, cross-dates on the basis of its position in the regional ceramic sequence to the early second millennium B.C. (Eyre 2006: 100, 161, 327). That evidence implies that early second millennium B.C. bronze is not limited to northern northeast Thailand.

This clear dating evidence from Ban Chiang will facilitate more precise extra-regional comparisons in order to illuminate the relationship of Southeast Asia's early metallurgy to that of other parts of the Old World. Expansion of archaeological research into formerly less studied parts of Asia has revealed the sporadic presence of copper-base metallurgy in the third millennium B.C. in a broad swath across central and eastern Asia (Chernykh 1992; Linduff 2000, 2004; Mei 2003). The Ban Chiang dating for early metallurgy will enable comparisons between the prehistoric metals technology in Southeast Asia and the metal technology of other parts of Asia to further investigations of the nature of regional relationships in the development of Old World technological systems.

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Notes

[1] All dating in this article is discussed in terms of calibrated dates. The calibrations given for the seven AMS dates discussed in detail in this article (Table 3, Fig. 3) are based on the IntCal04 calibration curve, which is the curve current at the time of submission of the article. The calibration program employed is OxCal v. 4.0.1. The calibrated ranges in this article may differ slightly from previously published calibrations, which were based on earlier calibration standards.

[2] For example, many variant interpretations of the dating of Ban Na Di have been published (*cf.*, Higham, Kijngam 1984a: 32; Higham, Kijngam 1984b: 57; Higham 1996a: 204; Higham, Thosarat 1998: 100; and Higham 2002: 138; Vincent 1984: 292). The duration of Ban Na Di's mortuary phase 1 has been interpreted as lasting as long as 800 years (Higham, Kijngam 1984c: 435) to as little as 200 years (Higham 1996a: 204). Such reinterpretations of chronology are symptomatic of the early stage of regional archaeological research when an insufficient number of sites have been excavated and dated to enable rigorous and comprehensive cross-dating, and in turn the development of comprehensive regional ceramic sequences. Eventually refinements from detailed cross-dating of Ban Na Di's ceramic sequence with ceramic sequences of other nearby sites in the area, combined with availability of high-precision dates pertinent to the area's ceramic sequence, will clarify the regional sequence for the Ban Na Di area.

[3] White (1986: 287-288) noted examples of metals and a crucible fragment associated with "densely incised" (i.e., i&i, or impressed and incised) pottery characteristic of Early Period Phase II burials.

[4] References by Southeast Asian archaeologists including White (1988a) and Higham (1996a: 56, 2002: 116) to the chronology for the Shang dynasty in China have been consistent with the official "Three Dynasties" chronology. This chronological framework dates the Early Shang to 1600-1300 B.C. and the Late Shang to 1300-1046 B.C. (see explanation in Thorp 2006: 24). The preceding Erlitou culture and the Xia periods are distinguished from the Shang, although research in the last few decades has shown that they may be considered part of the early "Bronze Age" of China. Thorp's (2006) recent book on the early Bronze Age of China proposes a narrowing of the definition of Shang to "the literate polity that flourished at Anyang in the last centuries of the second millennium B.C.E. [i.e., comparable to Late Shang] rather than assume that antecedent and contemporaneous cultures were also Shang" (Thorp 2006: 264). In this article, the traditional rather than Thorp's chronology is implied in the use of the term "Shang."

[5] White (1988a: 180) pointed out some differences between the metallurgy in prehistoric Thailand and that of the Shang dynasty. She noted that in prehistoric metal assemblages of Thailand, jewelry, especially bangles, is a prevalent artifact class and such items were probably lost-wax cast. Individual socketed implements were cast in bivalve molds. Hammering and annealing were practiced. In contrast, Shang metallurgy was characterized by piecemold-cast vessels; implements are commonly tanged; the bivalve molds of clay or stone sometimes produced multiple iterations of tanged implements like arrowheads. Bronze was not a medium for personal jewelry. Lost-wax casting appeared only in the 6th century B.C, and hammering and annealing are extremely rare in early Chinese Bronze Age metallurgy. While some socketed implements have been found in Shang contexts including the Yangtse valley Shang site Panlongcheng, derivation of the objects or prototypes from cultures peripheral to Shang where such items are characteristic, such as various Eurasian steppe cultures (Chernykh 1992), cannot be discounted.

In addition, technological styles for metal processing in the two culture areas differed. In prehistoric Thailand, small shallow crucibles were probably embedded in a pit, and the charge within the crucible was heated by fuel on top of the crucible, assisted by a draft of air directed on the surface. This procedure represents a refractory technology that differs from that used with the large, deep crucibles of the Shang (*cf.* Barnard 1980; Rehren 2003; Vernon 1997, 1996-1997). Barnard (1980) reconstructs the early "flower pot" Shang Erligang crucibles as having been externally heated in reverberatory furnaces, extrapolating in part from the external vitrification of the crucible walls along with the apparent close technological relationship between bronze metallurgy and the kiln-fired ceramic industry of the time. However, experiments by Chinese have found that the large, deep Panlongcheng Shang crucibles could have been internally heated outside a kiln with a properly designed blast apparatus inserted from above into the large crucibles (Hubei Institute of Archaeology 2001: 599-607; Plates 159-160). Barnard questions the feasibility of such a system in prehistory and notes the need to archaeologically identify remains of the blast apparatus to demonstrate that the Shang crucibles were internally heated (1980: 220).

[6] Bangles, socketed adzes/axes, and socketed spear points are common metal artefacts in early metal age societies in central parts of Asia (Chernykh 1992; see also Mei 2000, 2003).

[7] While this orientation change occurs at the same point in the ceramic sequences of both the BC (excavated in 1974) and BCES (excavated in 1975) locales, which are separated by about 100 meters, the two locales differ in terms of the orientation changes relative to cardinal points. During the Early Period Burial Phases I-IV, grave orientations were predominantly north/south at the BC locale, and north-northwest /south-southeast at BCES locale. Beginning with Early Period Phase V, grave orientations changed to predominantly northwest/southeast at BC and north/south at BCES.

[8] Some burial phases have been further subdivided into subphases with "a," "b," etc. in order to give an approximate relative stratigraphic position of individual graves with similar pottery. For example Early Period Phase V burials (skeletons with the appropriate orientation and Phase V ceramics) that appear to be those deposited earliest in the phase (cut from the lowest source) have been assigned to subphase "a" of Phase V. Phase V graves cut from higher (i.e., presumably later) sources have been assigned to subphase "b" or "c," depending on relative estimated source of grave cut.

[9] Inferring from size, shape, and metallographic analyses, Elizabeth Hamilton, personal communication.

[10] Although some have suggested that bioturbation such as by beetles (*e.g.*, Higham 1989: 110) has resulted in high rates of post-depositional disturbance of prehistoric sites in Thailand, Grave and Kealhofer (1999) have shown that bioturbation does not necessarily result in significant vertical movement of sediments.

[11] I.e., in the sense that the place of deposition was determined by ancient cultural and not by post-depositional activities, even if those cultural activities redeposited the materials from earlier positions.

[12] Including determinations from other portions of the Ban Chiang burial sequence, as well as experimental determinations on chemical fractions; see Hedges *et al.* (1989, 1992).

[13] Some scholars are currently advocating that all dates from Southeast Asia that do not conform to strict criteria such as AMS dates on "short-lived plant organisms that were demonstrably part of the diet" (Thomas and McLauchlan 2006: 194) be abandoned from consideration in dating cultural sequences. The author's opinion is that the field of Southeast Asian archaeology "is not there yet." There are so few dates meeting their definition of "high precision" available from Southeast Asian sites (not to mention neighboring regions) that little absolute chronology would be left after such an exercise. Almost all comparisons within the prehistoric period between sites, among sub-regions, and between major regions and culture areas would cease under these strictures. Moreover, it is understood by many Southeast Asian archaeologists that the degree of resolution possible for many problems in regional prehistory is coarse for now. Often "within the correct half millennium," and when lucky, the correct third of a millennium (early, middle, or late) are adequate for many issues (even if much ink is spilled in arguments over differences of a century or two). While specific "dates" such as c. 1000 B.C. are used in many published chronologies, reading the "fine print" and background literature often shows such phrasing is used for its greater convenience in comparison with a wordier version more reflective of radiocarbon imprecision, such as 'end of the second to the beginning of the first millennium B.C." While all regional archaeologists welcome improvements in dating, most realize they live in an imperfect world, and archaeology is an imperfect science. Judiciously using the extant data will be necessary until the quantity and quality of dating evidence from "high precision" sources like well-provenienced dietary remains outweigh and supersede the evidence, older or not, from less perfect sources. For the time being, Southeast Asian archaeologists (and those from other parts of the archaeological world reliant on radiocarbon dating) know they must tolerate some degree of chronological fuzziness as well as periodic shifts in the chronological understanding as better evidence and better interpretations of the evidence accumulate.

[14] Dates from charcoal or wood may be substantially older than the deposit from which the dated material was excavated. Examples include if the charcoal or wood came from core portions of a long-lived tree, or if the wood was reused over a long period, such as a wooden pile that might be used for several successive houses over generations before entering the archaeological record (Thomas, McLauchlan 2006). Similarly, dates on artefacts that might have been heirlooms, passed from generation to generation before entering the archaeological record as perhaps a grave good, may also provide a distorted picture of the age of the depositional event. Precaution against these biases should include internal coherency of dates within a site, cross-dating between sites, and multiple lines of evidence including dating different kinds of deposits and more than one type of material (*e.g.*, charcoal from short-lived plant parts and rice remains).

[15] This flat piece of bronze from BCES Burial 72 was termed a "nodule" in White 1997. The object was since placed in the class of "Flat" pieces.

[16] Excavators did not identify clear grave cuts for these two burials, but other evidence indicates the bodies were interred. The metal-related evidence was recovered during removal of grave contents, and hence it is inferred that the metal evidence was in the grave fill.

[17] Three of these four small artefacts were too corroded for technical analysis, but one of these artefacts contained enough uncorroded metal to allow it to be analyzed metallographically. It exhibited a dendritic structure indicative of cast copper-base metal, and its yellowish color suggests it is likely a bronze alloy (Elizabeth Hamilton, personal communication). Since no ore pieces such as malachite have been identified at Ban Chiang, it is likely that the other three green metallic pieces that could not be analyzed are also cast copper-base metal.

[18] Too corroded for technical analysis.

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