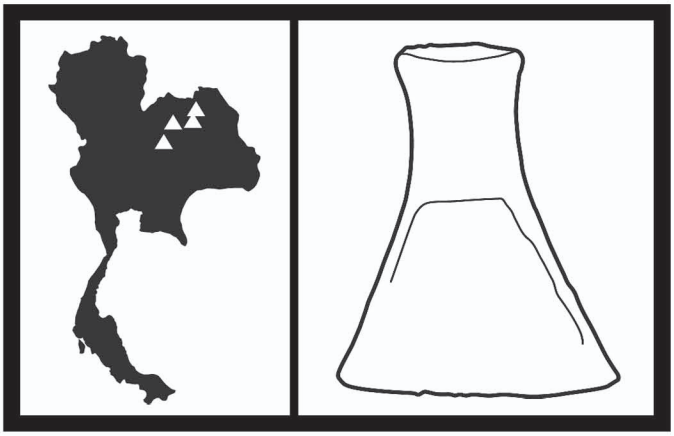
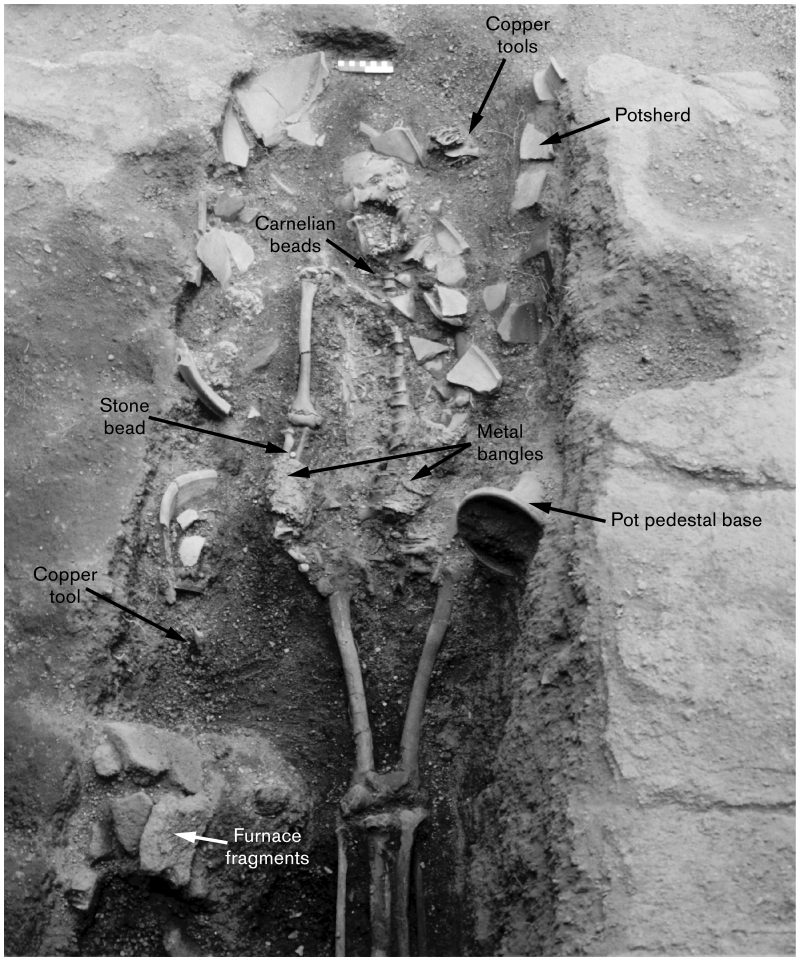
BAN CHIANG, NORTHEAST THAILAND, VOLUME 2C: THE METAL REMAINS IN REGIONAL CONTEXT



BAN CHIANG, NORTHEAST THAILAND, VOLUME 2C: THE METAL REMAINS IN REGIONAL CONTEXT



Founder's burial from Nil Kham Haeng in the Khao Wong Prachan Valley, Lopburi Province, central Thailand dating ca. mid-1st millennium B.C. Among the grave goods of this adult male burial were the disassembled sections of a complete furnace chimney by his right knee. Typical copper-base cordiform implements near the head were most probably cast on site. (Burial 1 from Operation 4 of TAP'90)

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Joyce C. White and Elizabeth G. Hamilton, editors

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DEDICATION

This volume is dedicated to Helena Kolenda, Program Director for Asia at the Henry Luce Foundation, and Leslie Kruhly, Vice President and Secretary of the University of Pennsylvania and former Development Director of the Penn Museum. We are deeply grateful for their unceasing encouragement and belief in us and our work, and for their strategic assistance in the continuation of the Ban Chiang Project at the Penn Museum. Their support made the preparation of the monograph suite on Ban Chiang metallurgy possible.

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1

Providing a Regional Socioeconomic Context for Prehistoric Metallurgy in Thailand

Joyce C. White

technological change results from the decisions and consequent activities of many people—their contemporaries and their predecessors. (Schiffer 2011:188)

Metal technologies practiced by prehistoric peoples are inherently social activities. Complex multi-community interactions and specialized knowledge were needed to create products from dispersed natural resources, and to get those products to consumers often located hundreds of kilometers away from the raw materials. As reviewed in TAM 2A, chapter 3, the study of the prehistoric development of metallurgical technologies has moved far beyond Childean perceptions. The narratives now emerging from archaeometallurgical studies acknowledge that there have been many ways past communities have produced and distributed metal products and that consumer bases were diverse. Because the raw materials and specialized knowledge were so widely dispersed, and metal and metal artifact production so often required regional social networks, archaeometallurgy can provide an intimate window into past societies.

Since the excavation of copper-base objects at Ban Chiang and other sites in Thailand during the 1960s and 1970s, many metal age sites in Southeast Asia have been explored, and much more is now known about the regional picture for the prehistoric metallurgy of Thailand. Whereas TAM 2B presented in-depth data and analyses from four sites in northern northeast Thailand, Ban Chiang, Ban Tong, Ban Phak Top, and Don Klang, this volume strives to review and synthesize the excavated archaeometallurgical evidence now available in English from two larger parts of Thailand, the northeast and the central portions. These two regions are drained by the middle Mekong and Chao Phraya Rivers. Metallurgical evidence from these two areas facilitates providing a regional societal framework for the detailed data presented in TAM 2B.

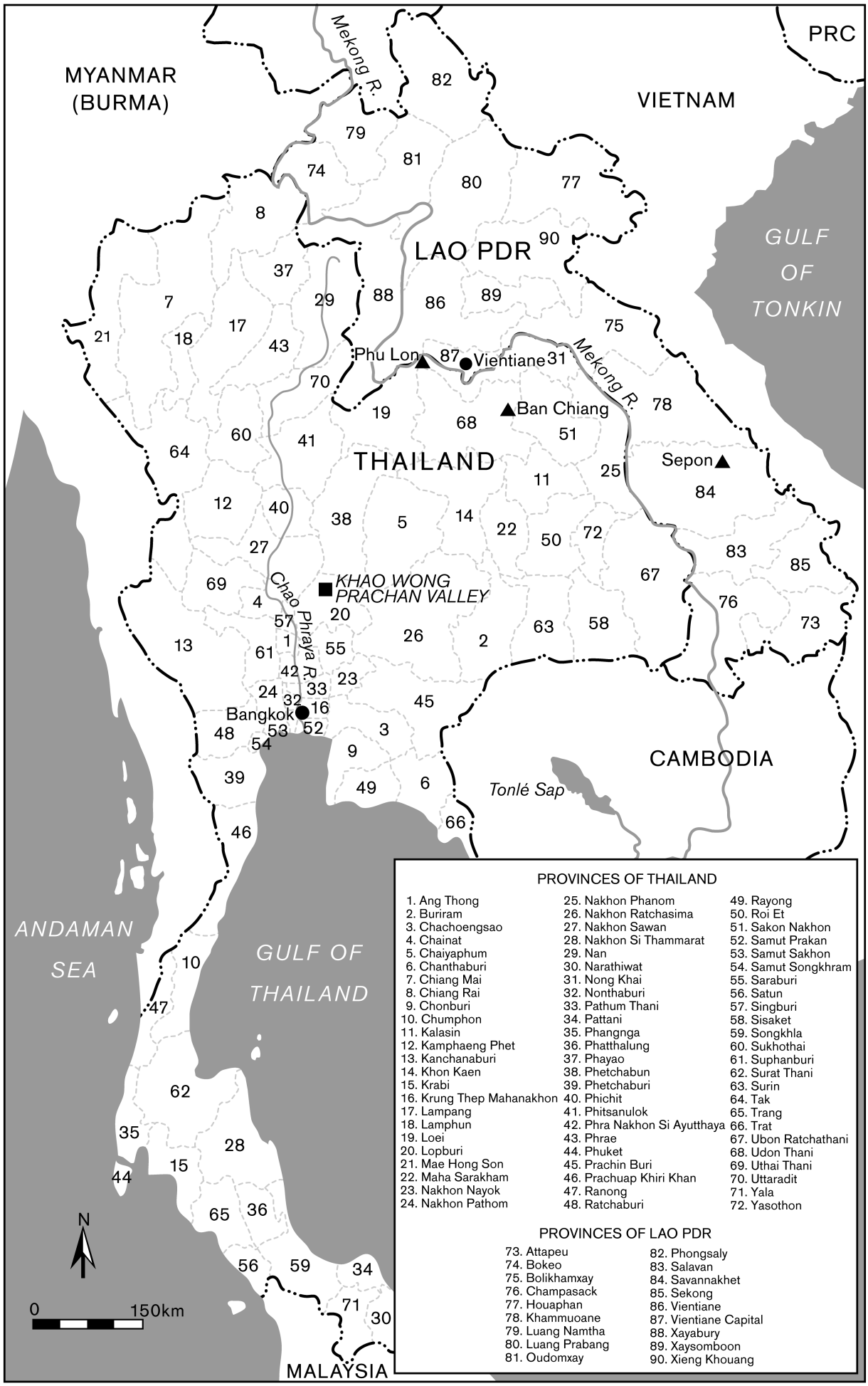
Excavations have occurred not only at prehistoric consumer sites like the four in this study, but also, importantly, at several primary production locations. These excavations were conducted by the Thailand Archaeometallurgy Project and other research programs. As this volume will show, a regional picture with great cultural specificity is emerging that illuminates the production of metals, the manufacturing of metal products, the distribution of those products, and the consumption of those products in metal age Thailand. This synthesis should allow Southeast Asia to take its unique place in global archaeometallurgy as the Southeast Asian Metallurgical Province. The metallurgical details, along with other archaeological evidence, also reveal how metal age communities interacted with each other over millennia to maintain peaceful middle-range societies via regional economic networks.

To begin the articulation of the prehistoric metallurgical system, Chapter 2 by Vincent Pigott reviews the evidence for primary production of copper from central and northeast Thailand, as well as from central Laos. Both mining and smelting sites

are discussed. Recently available lead isotope analyses for a small sample from two of the four study sites relative to known metal production locations are presented in Chapter 3 by Oliver Pryce. These analyses are beginning to provide the first evidence for specific networks linking metal production localities with consumer groups in prehistoric Thailand. In Chapter 4, the archaeometallurgical evidence that has accrued over the past five decades mainly from consumer societies in the middle Mekong and Chao Phraya Valleys is compiled. Many of these data reside in hard-to-find publications, theses, and manuscripts, yet when pulled together, the data are actually quite extensive. This effort, shouldered primarily by Elizabeth Hamilton, is important as there has been a trend to generalize about ancient metallurgy in Thailand based on selected finds from the most recent excavations. This more comprehensive study puts together quite a different view, a regional picture that demonstrates noteworthy variability in consumer demand. To assist readers with situating the provinces of sites mentioned in these chapters, Fig. 1.1 designates the provinces of Thailand and Laos. Chapter 5 synthesizes the production and consumption evidence to articulate what can now be said about metal technological systems in prehistoric Thailand. Chapter 6 strives to place the archaeometallurgical evidence from central and northeast Thailand into socioeconomic context for an updated narrative on the social implications of prehistoric metallurgy in this part of the world. The evidence illustrates a regionally distinctive configuration for ancient metallurgy as one of integrative activities that knit together a regional exchange system that endured for hundreds of years, and possibly for two millennia. A critique is also presented of the currently prevalent Higham Model for metal age Thailand.

Placing the Ban Chiang metal remains in their larger regional context highlights one of the major contributions of this site to global knowledge of human societies and to understanding relationships between society and technology. Although there may be a two-way street of influence between cultures and technologies, ultimately cultures dominate the choices past societies made in adopting and practicing any technology. The Ban Chiang and Southeast Asian evidence provide an excellent case study against technological determinism; instead, the drivers of technological adoption and change during the metal age in Southeast Asia were local communities.

Figure 1.1 *facing* Provinces of Thailand and Laos


MYANMAR (BURMA)
PRC
VIETNAM
LAO PDR
THAILAND
CAMBODIA
MALAYSIA
GULF OF TONKIN
GULF OF THAILAND
ANDAMAN SEA
Mekong R.
Mekong R.
Chao Phraya R.
Phu Lon
Vientiane
Ban Chiang
Sepon
KHAO WONG PRACHAN VALLEY
Bangkok
Tonlé Sap
N
0
150km
PROVINCES OF THAILAND
1. Ang Thong
2. Buriram
3. Chachoengsao
4. Chainat
5. Chaiyaphum
6. Chanthaburi
7. Chiang Mai
8. Chiang Rai
9. Chonburi
10. Chumphon
11. Kalasin
12. Kamphaeng Phet
13. Kanchanaburi
14. Khon Kaen
15. Krabi
16. Krung Thep Mahanakhon
17. Lampang
18. Lamphun
19. Loei
20. Lopburi
21. Mae Hong Son
22. Maha Sarakham
23. Nakhon Nayok
24. Nakhon Pathom
25. Nakhon Phanom
26. Nakhon Ratchasima
27. Nakhon Sawan
28. Nakhon Si Thammarat
29. Nan
30. Narathiwat
31. Nong Khai
32. Nonthaburi
33. Pathum Thani
34. Pattani
35. Phangnga
36. Phatthalung
37. Phayao
38. Phetchabun
39. Phetchaburi
40. Phichit
41. Phitsanulok
42. Phra Nakhon Si Ayutthaya
43. Phrae
44. Phuket
45. Prachin Buri
46. Prachuap Khiri Khan
47. Ranong
48. Ratchaburi
49. Rayong
50. Roi Et
51. Sakon Nakhon
52. Samut Prakan
53. Samut Sakhon
54. Samut Songkhram
55. Saraburi
56. Satun
57. Singburi
58. Sisaket
59. Songkhla
60. Sukhothai
61. Suphanburi
62. Surat Thani
63. Surin
64. Tak
65. Trang
66. Trat
67. Ubon Ratchathani
68. Udon Thani
69. Uthai Thani
70. Uttaradit
71. Yala
72. Yasothon
PROVINCES OF LAO PDR
73. Attapeu
74. Bokeo
75. Bolikhamxay
76. Champasack
77. Houaphan
78. Khammuoane
79. Luang Namtha
80. Luang Prabang
81. Oudomxay
82. Phongsaly
83. Salavan
84. Savannakhet
85. Sekong
86. Vientiane
87. Vientiane Capital
88. Xayabury
89. Xaysomboon
90. Xieng Khouang

2

Prehistoric Copper Mining and Smelting in Southeast Asia: Evidence from Thailand and Laos[1]

Vincent C. Pigott

Introduction

There is little at or in archaeological sites that remains static over time. Bioturbation, leaching, organic decay, and erosion are among the various natural agencies at work at sites and on the artifacts contained within over the *longue durée*. Site formation and degradation processes continue well after human occupation has come to an end. Thus, entropic change is inevitable; nothing remains the same. The discipline of archaeology also exists in a constant state of change, hopefully not entropic, but change just the same. Furthermore, archaeological interpretation is subject to incessant change, i.e., reinterpretation, and nothing in archaeology is more vulnerable to change than chronology. Southeast Asian archaeology as a comparatively nascent Old World discipline has experienced more than its fair share of chronological reinterpretation in recent decades (see TAM 2A, chapters 1 and 3). Significant light has been shed on chronology and its vagaries in the context of prehistoric Thailand and in relation to the site that is the primary focus of this monograph, namely Ban Chiang (see TAM 2A, chapter 2, for a detailed discussion).

With this in mind, the discussion now turns to the Khao Wong Prachan Valley (KWPV) in central Thailand, the focus of Thailand Archaeometallurgy Project (TAP) research and of this chapter. The TAP is currently in the midst of a new dating initiative based on accelerator mass-spectrometry (AMS) dates from domestic seeds (e.g., millet, rice) and charcoal excavated from sites in the KWPV. Until his untimely death in late Spring 2019, Andrew D. Weiss (Consulting Scholar, Penn Museum) was directing the TAP AMS 14C dating program. The author will now assume this role. The TAP samples are being dated at the Oxford University Radiocarbon Accelerator Unit (ORAU) by Drs. Thomas Higham and Katerina Douka. This research is funded by New Zealand's Marsden Foundation, and is part of a larger, pan-Mainland Southeast Asian dating program directed by Professor Charles Higham (University of Otago, Dunedin) entitled "The Passage of Time. Dating the Prehistory of Southern China and Southeast Asia." The essential archaeobotanical research behind the TAP dating program has been conducted by a team from Washington State University, namely Professor Steven Weber, Professor Jade d'Alpoim Guedes (now of the University of California, San Diego), and Sydney Hanson.

Once the current AMS dating program is complete, close to 100 new seed and charcoal samples from TAP sites will have been dated and the results interpreted. Substantial refinement to the Lopburi regional *working* chronology is expected (Rispoli et al. 2013:109, fig. 4) with the anticipation that the KWPV site chronology will prove to be earlier than presently understood. However, in this regard it must be noted that any discussion of ^{14}C dating in the KWPV must contend with that portion of the ^{14}C B.P. date to calendar date correction curve

known as the Hallstatt plateau, where any radiocarbon dates between 2570 and 2350 B.P. all resolve to 800–400 B.C. (Millard 2008) with only a few post-plateau dates present (Andrew D. Weiss, pers. comm. 2019). Both Non Pa Wai and Nil Kham Haeng have dates that fall into this zone, limiting the precision of the corrected dates during this all-important period of site occupation and associated industrial scale copper production in the KWPV.

Pending the analysis and publication of the results from the new TAP AMS dating program, the chronology adopted for early copper production at Non Pa Wai is currently based on an earlier series of radiocarbon dates that place this transition in the later 2nd millennium B.C. (see Rispoli et al. 2013), with intensive, large-scale copper production at the KWPV's enormous smelting sites proceeding well into the 1st millennium B.C. (see below Table 2.2). Furthermore, the upshot of the current interpretation is that Non Pa Wai and Nil Kham Haeng appear to have more temporal overlap than previously anticipated (see below Table 2.2). How and why two such massive smelting sites could evolve at about the same time and in proximity to one another are questions for TAP's continuing investigations.

It must be emphasized that much of the interpretation and discussion concerning prehistoric metallurgical activity and its chronology in the KWPV presented in this chapter should be considered as preliminary in the light of the fact that the final reports for the TAP sites of Non Pa Wai, Nil Kham Haeng, and Non Mak La remain unpublished.

Three Locations with Copper Production Evidence

This chapter assesses evidence for early copper mining and smelting activity in two main locations, one in northeast Thailand and the other in central Thailand, and briefly overviews recent evidence from the mining complex at Sepon in Laos. The first location, the Phu Lon Copper Mining Complex (hereafter Phu Lon Complex), is situated along the southern bank of the Mekong River in the northwestern sector of northeast Thailand in Amphoe Sang Khom, Nong Khai Province. Because the Phu Lon Complex is located so close to the eastern border of the province of Loei where many copper and other ore deposits are known, the site is referred to as situated in the greater Loei region. Here copper mining that dates to the 1st millennium B.C. is associated with ore processing and smelting.

The second major early metalworking location is found some 400 km to the south in the KWPV, in Amphoe Kok Samrong and Amphoe Muang, Lopburi Province, located in the Chao Phraya Drainage of central Thailand (see TAM 2A, fig. 6.4). The KWPV has documented evidence of primarily 1st millennium B.C. metallurgy at two massive smelting sites, Non Pa Wai and Nil Kham Haeng, which also yielded evidence of habitation. A third nearby site, Non Mak La, has revealed a habitation/mortuary area and a separate metalworking locus.

Also in Lopburi Province, evidence of metallurgy is found in the neighboring Khao Sai On Mineral District (hereafter KSOMD) south of the KWPV. Excavations at the sites of Khok Din and Noen Din have revealed a copper production technological system similar to that employed at Nil Kham Haeng, but on a much smaller scale. Brief mention is made of a third primary copper mining and smelting cluster of sites in central Laos at Sepon. Geologically speaking, the deposit at Sepon is massive, but much of the deeper-lying portions of the orebody remained inaccessible to prehistoric miners. Current research should provide a good sense of just how important these deposits were to the inhabitants of the middle Mekong region in prehistory.

Overall, the above-mentioned six sites from Thailand provide the best archaeological evidence known thus far for prehistoric mining and/or metallurgy in the middle Mekong and Chao Phraya Basins and therefore are key to understanding the technological systems employed to produce copper in this region. Copper produced at the sites described here likely supplied many prehistoric settlements in the greater region.

As reviewed in TAM 2A, chapter 6, given the alluvial geology of northeast Thailand's vast Khorat Plateau, viable non-ferrous ore sources are unlikely to be found in any abundance in its Sakon Nakhon Basin where the sites of the Ban Chiang cultural tradition are located. The same is true for northeast Thailand's Phimai region in the upper Mun Valley, another region well-populated in prehistory.

Within Thailand, the lack of ore sources in these regions removes a substantial portion of the country from the realm of possible ore-providing zones and necessitates that evidence for ore sources be sought elsewhere. At the same time, at sites across northeast Thailand, evidence not only for finished products, but also for metalworking (e.g., casting of copper-base metal products) is archaeologically well documented (see TAM 2B, chapter 5, and Chapters 4 and 5, this volume). Thus, the metal found at the prehistoric mortuary/occupation sites in the Sakon Nakhon and upper Mun Basins must have been imported from other localities.

The Phu Lon Complex does have evidence for tin bronze alloying. In the KWPV, at Nil Kham Haeng, tin bronze is also evidenced in a very small number of artifacts from burials. Slag analyses from the site also show traces of tin perhaps reflective of recycling of metal (Pryce et al. 2010:255) or, perhaps of tin bronze production itself. Moreover, the possibility that tin bronze artifacts arrived via trade and exchange cannot be ruled out. The scale of mining evidence and accumulated production debris as well as the paucity of metal artifacts at the sites discussed herein suggest that some form of finished product, most likely the intermediary product of copper-base metal ingots, was being exported to other regions. Copper ingots, for example, could have been transported from any of these production sites to villages in the Sakon Nakhon Basin and elsewhere in Thailand as well as the larger region to be cast into implements, jewelry, and other finished products, often after having been alloyed with tin. Excavations at Sakon Nakhon Basin settlements have yielded numerous finished copper-base products, along with evidence suggestive that local metalworkers produced copper alloys, including tin bronze, and, in turn, manufactured such metal products from these alloys. In fact, a strong argument has been made that copper from central Thailand (i.e., the KWPV), and perhaps later artifacts or ingots in tin bronze, were moving to sites in the Phimai region during phase BA2 (1000–900 B.C.) at Ban Non Wat (Pryce 2012a; Pryce et al. 2011a:3320; see map in Higham and Rispoli [2014:3, fig. 1]; see also discussion below). Thus, final manufacturing steps may well have occurred in proximity to consumers, and, as a result, finished products were adapted to local needs and tastes. Some evidence is also discussed that links ore-processing behaviors in Loei to those in Lopburi Province.

Ore Sources and Early Mining Exploitation

As described in TAM 2A, chapter 6, understanding the prehistoric metallurgical industry in the region begins with the study of the geology of the region's metallogenic zones (see TAM 2A, figs. 6.4 and 6.5). In northeast Thailand, the Khorat Plateau that makes up much of the region is a vast expanse of alluvium divided by the Phu Phan Hills into two shallow basins, the Khorat and the Sakon Nakhon (see TAM 2A, fig. 6.2); the two basins lack deposits of non-ferrous base metals such as copper, lead, and zinc.

Before and after the excavations at Ban Chiang in the 1970s, teams of Thai and international geologists conducted numerous extensive surveys in northeast Thailand (e.g., Jacobson et al. 1969). The best-known ore-rich region near the Khorat Plateau is in Loei Province, which abuts the Plateau along much of its long western escarpment. Decades of economic geological surveys in the region, some conducted by Udom Theetiparivatra of the Thai Department of Mineral Resources, show how rich and diverse the ore deposits of Loei Province are (Javanaphet 1969: fig. 5.6). Evidence of pre-modern mining activity at the Phu Lon Complex was identified during these early Thai geological surveys.

At the second mineral-rich location well to the south in the KWPV on the alluvial Lopburi Plain in central Thailand, economic geological surveys have been few. While the inselbergs that edge this valley have copper deposits, the greater region is devoid of such resources. Nonetheless, the KWPV's inselbergs do show evidence of pre-modern, presumably ancient mining (Natapintu 1988:115, table 2; for a brief overview of the environment of the KWPV see Higham and Rispoli [2014:4]).

Despite decades of archaeological work in Thailand, few projects have focused on identifying primary copper production sites, and, so far, no other known ore deposits with evidence of prehistoric mining have been identified in the country other than those at the Phu Lon Complex and in the Lopburi

region. Evidence of pre-modern/ancient mining from elsewhere in Southeast Asia remains sparse, with the exception now of Sepon in Laos where investigations have identified prehistoric copper shaft mining across the surface of a major orebody. This mining activity has been dated to the early 1st millennium B.C. (MMG LXML Sepon 2016; Pryce et al. 2011a:3310; Sayavongkhamdy et al. 2009; Tucci et al. 2014). Beyond the Thai and Laotian evidence, at present, one has to look outside Southeast Asia to the north into the People's Republic of China (hereafter PRC) for additional evidence of substantial ancient copper mining (e.g., Shizong et al. 1993; Vogel 1982; Wagner 1986). Investigation of other metal-ore-rich regions of Southeast Asia is essential for an improved understanding of prehistoric metallurgical developments across the greater region.

Current data on the Phu Lon Complex resulted from survey and excavations by TAP (e.g., Natapintu 1988; Pigott 1988, 1998; Pigott and Natapintu 1988, 1996–97; Pigott and Weisgerber 1998; Pigott et al. 1992; Pryce 2012a; Pryce et al. 2011a, 2011b, 2014; Vernon 1996–97; White and Pigott 1996).

The evidence from central Thai sites is the result of archaeological fieldwork and subsequent research conducted first by Surapol Natapintu (then of the Fine Arts Department) and the Central Thailand Archaeological Project (e.g., Natapintu 1984a, 1984b), followed shortly thereafter by both the TAP and the Thai-Italian Lopburi Regional Archaeological Project (LoRAP). In central Thailand, TAP has focused on documenting ore sources exploited and high temperature processes used at prehistoric copper smelting sites that were, to varying degrees, both habitation and production sites (e.g., Higham and Rispoli 2014; Natapintu 1987, 1988, 1991; Pigott 1999; Pigott and Natapintu 1988, 1996–97; Pigott et al. 1997, 2006; Pryce 2009, 2012a, 2012b; Pryce and Pigott 2008; Pryce et al. 2010, 2011a, 2011b, 2014; Rispoli et al. 2013; Weiss 1989; White and Pigott 1996). LoRAP focused on the satellite industrial locus of the KSOMD, south of the KWPV, where small-scale copper production exploited nearby pockets of copper ores also during prehistory (Ciarla 2007b, 2008; Higham and Rispoli 2014; Pryce et al. 2013; Rispoli et al. 2013). The data from the TAP and LoRAP research programs provide the bulk of the empirical evidence presented in this chapter.

Northeast Thailand: The Greater Loei Region

The Phu Lon Complex: Mining and Smelting

For purposes of discussion, the following terms, as defined herein, are used to refer to the Phu Lon Mining Complex as well as to distinct activity areas on the grounds of the Complex:

- *Phu Lon Complex*: the entire area of prehistoric and later mining and smelting activity located on and surrounding two hills (I and II) containing copper orebodies on the south bank of the Mekong River at 18°204 N, 102°140 E (see Pryce and Abrams 2010).

- *Phu Lon I*: (For location see Figs. 2.1 and 2.2.) The hill/orebody situated immediately south of the Mekong River. This is the location of the majority of the mining evidence visible on the surface. Various mining locations named but not individually discussed can be found on Figure 2.2.

- *Phu Lon II*: (For location see Fig. 2.1.) This hill/orebody is located immediately to the south of Phu Lon I, separated from it by a narrow valley between the two hills. Modest mining rubble deposits were apparent on Phu Lon II along with a large ore-crushing anvil (see Fig. 2.12), suggesting that processing of mined ore took place here as well.

The TAP site survey in Loei Province in 1984 included one week of test trench excavation at the locus known as the Pottery Flat at Phu Lon I, undertaken by Surapol Natapintu, Udom Theethiparivatra, and the author, with the assistance of a team from the Northeast Thailand Archaeological Project (NETAP) based in Khon Kaen and of local workers (Pigott 1984). This was followed by a three-month excavation season in 1985 (Pigott 1985). This fieldwork demonstrated that over the centuries numerous prospecting pits, adits, shafts, and galleries had been opened at the Phu Lon Complex, evidencing extensive mining activity dating primarily to the 1st millennium B.C. (see Fig. 2.3 and Table 2.1). These