

CURRENT RESEARCH ON PREHISTORIC COPPER-BASED METALLURGY IN THAILAND

by SURAPOL Natapintu

During the past 2 decades we have gained much information about the history of copper-based metallurgy in Southeast Asia through work carried out in northeastern Thailand. Analyses of bronze materials from Non Nok Tha and Ban Chiang indicate that the ancient Thai metalsmith understood well most of the basic techniques of copper/bronze metallurgy since the early period of bronze using in this area. The development through time of the technology is discussed by Stech Wheeler and Maddin (1967:47) who noted that

".....Metallurgy in Thailand was not static after the early development of the basic techniques of bronze working, since smiths continued to experiment and achieved results which had, at least, cosmetic significance."

However, archaeologists interested in ancient metallurgy continued to believe that the history of bronze in Southeast Asia is still incomplete. This is due to the fact that past researches and analyses, though important, have yielded evidence indicating only the existence of bronze manufacturing, types of alloys, and techniques of fabrication. No archaeological evidence of raw material procurement and processing has yet been properly studied.

Archaeologists of the Archaeology Division of the Thai Fine Arts Department have therefore put more effort into the study of archaeometallurgy in Thailand. These efforts were rewarded in 1984 when archaeological work began at a large prehistoric copper mine in northeastern Thailand, and at a major copper production centre in Central Thailand.

The current research on copper-based metallurgy presented here includes (a) work conducted by the Thailand

Archaeometallurgy Project*, a joint project between the Thai Fine Arts Department and the University Museum of the University of Pennsylvania, specially organized for the investigation of the origin and development of metal using in Thailand, and (b) work conducted by the Central Thailand Archaeological Project (CTAP) of the Thai Fine Arts Department. This research will be described separately according to the geographical setting of the sites involved, namely Northeastern and Central Thailand.

NORTHEASTERN THAILAND

The most recent research concerning prehistoric copper based metallurgy in this region of Thailand is that carried out by TAP in 1984 and 1985. Existing resources of base metal ores (copper-lead-zinc) as well as archaeological sites containing metallurgy-related materials were visited and studied by the team. A summary of researches in those two seasons has already been presented elsewhere (See Pigott 1984, 1985; Pigott et al. n.d.). Therefore, the present chapter will describe only the most interesting site, Phu Lon (ภูโลน) a copper mining complex located in Sangkhom District, Nongkhai Province.

The area of Phu Lon was originally located by archaeologists associated with the feasibility study programme of the Pha Mong Dam Project. It was those people who later informed Mr. Udom Theetiparivatra, an economic geologist of the Department of Mineral Resources (DMR), about green staining observed on rocks at Phu Lon. Mr. Udom's report to the DMR suggested that Phu Lon was an ancient copper mine. A geochemical survey at Phu Lon was then initiated (Sutham et al. 1983).

TAP's team, guided and joined by Mr. Udom, visited Phu Lon in 1984. A brief test excavation was conducted at the area labelled "Pottery Flat", named after its quite flat appearance and the quantities of potsherds scattered on its

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This article was originally presented at the SPAFA Seminar in Prehistory of Southeast Asia held in Bangkok, Surat Thani, Phangnga, Phuket and Krabi, Thailand, on January 12-25, 1987.

*The Thailand Archaeometallurgy Project (TAP) was partly supported by the National Geographic Society.

surface. A single carbon sample from this test trench provided a calibrated date of ca. 450-395 B.C. (Pigott 1984). This was the first radiometric dating for a prehistoric copper mine in Thailand. It helped to convince TAP that an extensive excavation at Phu Lon had to be given priority.

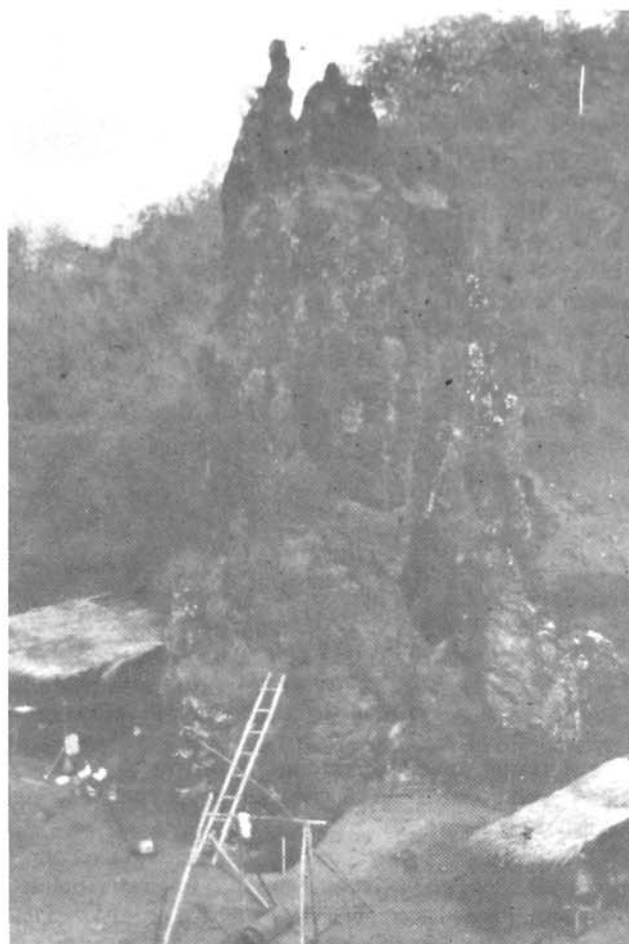
In 1985, with the assistance of the Northeastern Thailand Archaeological Project under the leadership of Mr. Sathaporn Kwanyuen, TAP's team, including Dr. Vincent Pigott of the University of Pennsylvania, Mr. Udom of the DMR and the writer who represented the Thai Fine Arts Department, conducted intensive excavations at the site of Phu Lon. Various individuals contributed specialized skills to the excavation: Prof. William W. Vernon, a geology professor at Dickinson College in Pennsylvania, U.S.A.; Dr. Roberto Ciarla of the Italian archaeological organization, ISMEO, based in Rome; Dr. Gerd Weisgerber, a mining archaeologist of the Deutsches Bergbau Museum in Bochum, Germany. Mr. Petar Glumac, a Ph.D. candidate from the University of California at Berkeley, also joined the work for a short period.

Excavations were conducted in 6 areas in Phu Lon, namely the Lower Flat, Peacock Cave, Upper Caves, Pottery Flat, Bunker Hill and Ban Noi Village.

In the Lower Flat, Peacock Cave and Upper Caves, several mine shafts and galleries were identified. The configuration of these mine shafts, as explained by Dr. Weisgerber, pointed to at least two levels of mining technology. The narrow winding shafts of the Lower Flat area suggested the use of metal tools, whereas the rounded configuration of the galleries at the Upper Caves indicated the use of stone tools in mining activities. The stone digging tools and mauls found randomly distributed in the layers of mining rubble and the metal pick blade marks sometimes observed in the walls of certain mine shafts also supported the idea of two distinct mining techniques.

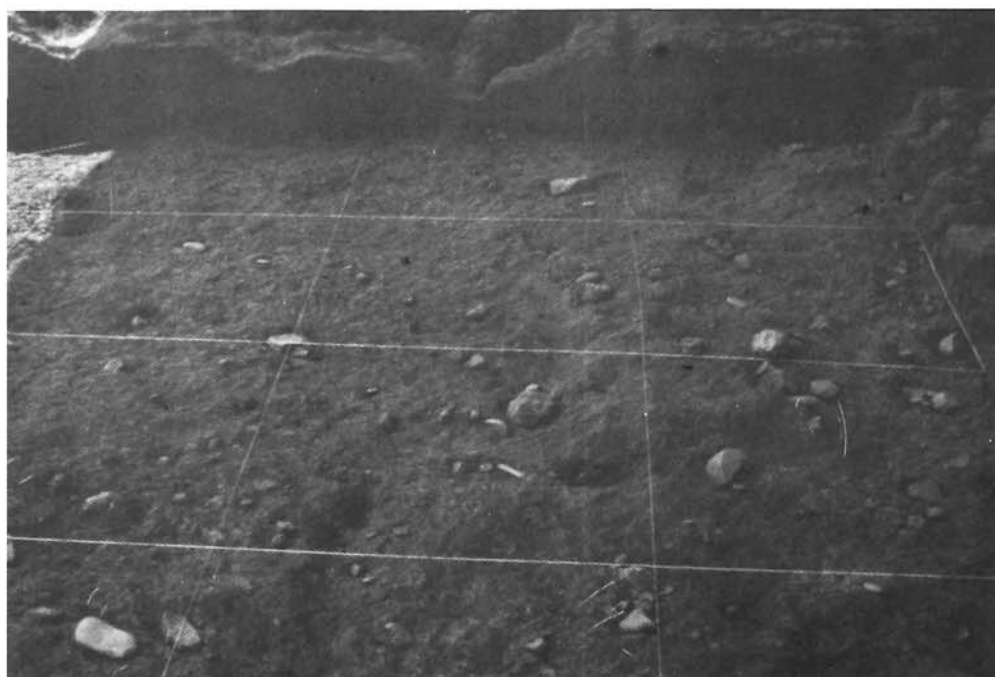
The operations conducted at these three areas included excavating the rubble fill from several mine shafts and trenching in front of certain shafts. It is evident that in that area, the predominant ore mined was malachite. There are strong indications that native copper was also available and exploited.

Most of the trenches could not reach bed rock. In fact, the excavation team was informed that a drill hole of the DMR showed that the mining rubble on the Lower Flat was at least 10 metres deep. However, our trenches, averaging 3-4 metres in depth, exposed quite a uniform stratigraphy in those parts of Phu Lon. The deposits consisted of mining debris. Some river cobbles of a volcanic nature (used as mining tools) and a small number of potsherds, the majority of which had cord-impressions, were found randomly distributed in these debris layers. Frequently, lenses of clean sand were found interspersed with layers of mining rubble. The clean sand beds or lenses were believed to indicate temporary pauses in mining activities. The overall pattern was one short term mining in successive intervals over an extended period of time.



Excavation of a mine shaft at Phu Lon, Nong Khai Province in 1985.

A larger scale excavation was also undertaken at the Pottery Flat, where a 1984 test trench had provided a C14 date of 450-395 B.C. The excavation confirmed that there was only a single archaeological stratum at this locality. However, now we know that the stratum varies in thickness from 30 cms. to just a few cms., and that it covers an area of at least 60 metres wide and 90 metres long. It comprised primarily of pea-sized gravel interspersed with larger skarn and rock fragments. These are the "gangue", or the discarded residue from the process of crushing the mined skarn and picking out the ore. The stratum also yielded enormous quantities of cord-marked potsherds, charcoal, malachite fragments, stone crushing/grinding tools and anvil fragments, polished stone adzes, ceramic crucible fragments, pieces of stone bracelets, and fragments of sandstone and ceramic moulds, as well as a broken clay animal figure with a curvilinear incised design. The volume of crushed skarn indicates that ore processing was the dominant activity at Pottery Flat. The mined ore was crushed on flat anvil stone with small handheld small cobble crushers or grinders. Clusters of tools and anvils in association with malachite bits and crushed skarn were found distributed on the surface



Excavation at Pottery Flat, Phu Lon, Nong Khai Province showing grid where clusters of artifacts were found: ore fragments, anvils and pestles or crushers.

of the stratum at various locations. Presumably, malachite and possibly native copper were being hand collected and transported elsewhere.

Numerous crucible fragments, some with green copper dross adhering, and two casting mould fragments pointed to the presence of metal working activities at Pottery Flat. Since we found no smelting slag there, it is reasonable to surmise that these activities were limited to the melting and casting of native copper. However, the possibility of the crucible reduction of malachite ore was also suggested. Tylecote (1974) and Pigott (1985:173) noted that crucible smelting of high purity malachite was possible, and that the process would not produce large quantities of slag.

The substantial amounts of charcoal at the Pottery Flat, which exceeded the amount likely to be derived from solely domestic activities, also suggested metal working, either native copper melting and/or the reduction of malachite. The charcoal also pointed to the possibility that the mined ore might have been roasted to increase friability and thus to ease the process of ore crushing. Moreover, roasting would facilitate smelting by transforming the mined ore into a porous substance which could be reduced easily and at a temperature lower than that usually required.

Evidently, other activities took place on the Pottery Flat along with ore crushing and metal working. These activities included the knapping and grinding/polishing of stone adzes. A stone bracelet blank, a number of stone bracelet fragments and a few bracelet cores suggested that the stone workers did not confine themselves to making immediately useful tools.

Thus Pottery Flat at present is seen as an activity area devoted to a variety of industries. However, due to the absence of animal and fish remains, the interpretation of the Pottery Flat as a habitation area has to be regarded as unproved.

Other excavated areas at Phu Lon are the so-called Bunker Hill and Ban Noi Village. It is apparent that another mining and ore crushing operation was conducted at Bunker Hill. At Ban Noi Village, situated at the foot of Phu Lon Hill, three trenches were dug. The deposits exposed in all three trenches were quite similar, composed mainly of crushed skarn with characteristics resembling the archaeological strata on the Pottery Flat. Some distinctive thick-walled historic potsherds were found in the upper portion of the deposits. However, the basal level at Ban Noi might be contemporaneous with the Pottery Flat and Bunker Hill. This suggestion was based on the fact that the excavated areas share certain artifact types; namely, stone bracelets, polished stone adzes, and cord-marked potsherds. One copper/bronze socketed axe and a small quantity of smelting slag were also recovered in the Ban Noi trenches. These are crucial evidence in support of the idea that the processes of smelting, melting, and casting of copper were carried out in the area of Phu Lon.

The excavated materials from Phu Lon are now under laboratory investigation. It is hoped that, by combining the results of laboratory analyses with traditional archaeological studies of artifacts, it will provide us with a better understanding of prehistoric Southeast Asian copper-based metallurgy and will enable us to reconstruct the processes

involved in this technology. A more complete history of copper/bronze metallurgy in Southeast Asia can then be written.

CENTRAL THAILAND

The CTAP and the TAP have jointly been involved in two research projects on prehistoric copper-based metallurgy in Central Thailand. A group of copper production sites has been located in the area bounded by Khao Wong Prachan and its related mountains. The area is thus called Khao Wong Prachan Valley (Surapol 1985).

As of now, nine major copper production sites have been found. Moreover, through investigations by Mr. Udom, nine localities concerned with copper ore extraction activities have been identified in this area of Central Thailand.

A detailed geological description of the copper ore sources is still in preparation. However, general information about the mining sites is shown in Table 1. Data on the smelting sites appears in Table 2. The evidence from the smelting sites will also be separately, and briefly, described.

THA KAE

The site of Tha Kae was excavated twice, in 1980 by the present author and in 1983 by Rachanie Bannanurag of the Archaeology Division, Fine Arts Department. The deposits at the site are divided into three major phases of occupation. The earliest phase contains some burials with associated goods including pots with curvilinear incised designs, cord-marked pots, red pedestal bowls, shell disc beads, and shell bracelets. Some polished stone adzes and bronze bracelet fragments were also recovered from this phase.

Numerous stone bracelet fragments and bracelet blank cores attest the on-site production of stone bracelets during the early phase of occupation.

In the second phase at Tha Kae, several new types of pottery appeared along with iron artifacts and glass beads. Mr. Bhuthorn Bhumathon, the present head of the Lop Buri Museum who joined the excavations, found a burial of this second phase that contained an iron implement together with a very thin-walled bronze bowl covering the skeleton's face. Layers of glassy copper smelting slag belong to this phase. Several copper ingots of small shallow bowl shape and a number of ceramic bivalve moulds (one apparently for arrowhead casting) have been found as stray finds at Tha Kae; these are very possibly associated with the slag. Evidence pointing to a larger occupation area, and possibly a larger population as well, was also noticed (Surapol 1984).

The third phase of Tha Kae represents a protohistoric/early historic occupation. Artifacts similar to those usually recovered in the so-called enclosed or "Dvaravati" sites in Central Thailand characterize this phase. Contacts with distant areas are evidenced by a small clay "Roman" type lamp and silver coins bearing Indian-influenced symbols of belief (Bhuthorn 1986).

No radiometric dates from Tha Kae are available yet. The dating of the site, therefore, has to be based on comparison with artifacts from other dated sites including Kok Chareon (Watson 1979, Ho 1985), Lop Buri Artillery Camp, and Don Ta Phet (Glover et al. 1983, Glover 1983, Chin 1976). The present writer is convinced that the early phase of Tha Kae, the assemblages of which are comparable to those of Kok Chareon, can be placed safely within the second millennium B.C., if not earlier. The second phase of Tha Kae is

TABLE 1: COPPER ORE RESOURCES IN KHAO WONG PRACHAN VALLEY,
LOP BURI PROVINCE, CENTRAL THAILAND

NO	SITE NAME	LOCATION		TECHNIQUE/EVIDENCE OF ORE MINING/ EXTRACTING	MINERAL/ORE FOUND	
		VILLAGE	DISTRICT		TYPE	CHARACTERISTIC
1	Khao Wong Prachan	Huai Pong	Khok Samrong	open pit, ore crushing	magnetite, malachite	bedded
2	Khao Pha Daeng I	Phai Kwang	Muang		malachite, chrysocolla, azurite, pyrite, magnetite	outcrop
3	Khao Pha Daeng II	Phai Kwang	Muang	ore crushing	wollastonite, Malachite	float
4	Khao Pha Daeng III	Phai Kwang	Muang	open pit	wollastonite, malachite	float
5	Khao Phu Kha I	Army Aviation Center	Khok Samrong	mining shafts and adits, ore crushing	malachite, chrysocolla, epidote	bedded
6	Khao Phu Kha II	Army Aviation Center	Khok Samrong	mining adit	malachite	bedded
7	Phao Phu Kha III	Army Aviation Center	Khok Samrong	mining adit	malachite	bedded
8	Khao Phu Kha IV	Army Aviation Center	Khok Samrong	mining shaft	malachite	bedded
9	Khao Phu Kha V,	Army Aviation Center	Khok Samrong	ore crushing	malachite	outcrop

characterized by pottery resembling that of Lop Buri Artillery Camp, which has thermoluminescence dates of ca. 700 B.C. The phase is possibly dated to somewhere between the early first millennium B.C. and the beginning of the Christian Era. The third phase is not earlier than the first century A.D. and not later than the sixth century A.D.

LOP BURI ARTILLERY CAMP

This site has been well known among Thai archaeologists since the excavation there in 1964-1965, when a great quantity of metal objects were unearthed. A summary of the excavation and finds has been presented by the late Prof. Chin You-di (1967:56-58). It is apparent that an assemblage of more than 50 burials was recovered along with pottery and stone beads. Numerous bronze and iron objects were found in association with the burials. According to Prof. Chin You-di (1967:56-57), the human skeletons had either bronze, glass, or ceramic bracelets. Many skeletons had more than one bronze ring on a single finger, and one skeleton even wore a toe-ring.

The site was revisited by the writer in 1984. Some glassy copper smelting slag and skarn rock bearing traces of malachite were found scattered over the site. It is convincing that the ancient inhabitants of Lop Buri Artillery Camp also performed processing, smelting and casting of copper. There are two thermoluminescence dates for this site; 700 ± 166 , and 1224 ± 300 B.C. (see Bronson and Han 1972:323).

WAT TUNG SINGTO

Wat Tung Singto has not been excavated yet, but a

preliminary survey has been conducted. Evidence relating to copper/bronze metallurgy (including copper ingots, moulds for ingot producing and ceramic bivalve moulds) was accidentally found during the digging of a pond (CTAP 1985). Many potsherds, mainly of cord-marked and red slipped types, were present on the surface of the site. Some rounded stone-crushers of wollastonite bearing traces of malachite were also present, along with thin layers of finely crushed slag. The site is currently considered to belong to the first millennium B.C.

HUAI YAI AND HUAI YAI RESERVOIR

These two related sites consist of a pair of juxtaposed mounds, which were studied in 1984. It is evident that the site of Huai Yai, yielding artifacts comparable to the early phase of Tha Kae, can be placed in the second millennium B.C. while the site of Huai Yai Reservoir, containing burials with iron and bronze objects as well as carnelian and agate beads, dates to the first millennium B.C.

The sequence of prehistoric occupation here seems, therefore, to be divided into two major phases. The Huai Yai site represents Phase I while Huai Yai Reservoir represents Phase II.

Archaeological evidence from the earlier phase includes several burials with shell ornaments and curvilinear and coarse cord-marked pots. Discs of marine shell and "H" shape beads, recalling those from the upper level of Khok Phnom Di (which is now dated to the second millennium B.C.—Amphan Kijngam, pers. comm.), were also recovered from a burial of Huai Yai I. The most interesting evidence

TABLE 2: COPPER PRODUCTION SITES IN KHAO WONG PRACHAN VALLEY

NO	SITE NAME	LOCATION		ROCK/ORE FOUND
		VILLAGE	DISTRICT	
1.	Tha Kae (ท่าแค)	Tha Kae	Muang	
2.	Lop Buri Artillery Camp (ศูนย์การทหารปืนใหญ่)		Muang	skarn, malachite
3.	Wat Tung Singto (วัดทุ่งสิงห์โต)	Phai Kwang	Muang	malachite, wollastonite
4.	Huai Yai (ห้วยไผ่)	Huai Yai	Muang	malachite
5.	Huai Yai Reservoir (อ่างเก็บน้ำห้วยไผ่)	Huai Yai	Muang	
6.	Non Mak La (โนนผาปลา)	Huai Pong	Khok Samrong	malachite associated with quartz crystal, skarn, hematite, magnetite
7.	Non Pa Wai (โนนป่าหวาย)	Huai Pong	Khok Samrong	malachite, chrysocolla, chalcopyrite, hematite, magnetite, skarn
8.	Non Khok Wa (โนนกกหว้า)	Huai Pong	Khok Samrong	malachite, pyrite hematite, magnetite
9.	Nil Kham Haeng Reservoir (อ่างเก็บน้ำนิลขามแห่ง)	Army Aviation Center	Khok Samrong	Quartz crystals, epidote, skarn, malachite

from this phase is that which points to the contemporaneous on-site production of polished stone adzes, stone bracelets, and copper. Numerous prepared stone blanks, hammer stones, waste flakes, stone adze rough-outs, whetstones with use-marks, and both finished polished stone adzes constitute evidence of every step of stone adze manufacturing. A great quantity of flat and rounded stone bracelet blanks, bracelet blank cores, and stone bracelet fragments attests to an industry producing these ornamental items. And a substantial volume of copper smelting slag and crucible fragments are point clearly to the presence of copper smelting. Thus, Huai Yai site is seen as both a habitation area and an area devoted to various industrial activities.

The second phase of the Huai Yai area, represented by the site of Huai Yai Reservoir, is characterized by burials with different pottery types and iron implements. Copper smelting continued during this phase. However, smelting techniques seem to have been more advanced as suggested by a distinctive glassy slag that may indicate higher furnace temperature and a better recovery of metal from the ore.

NON MAK LA

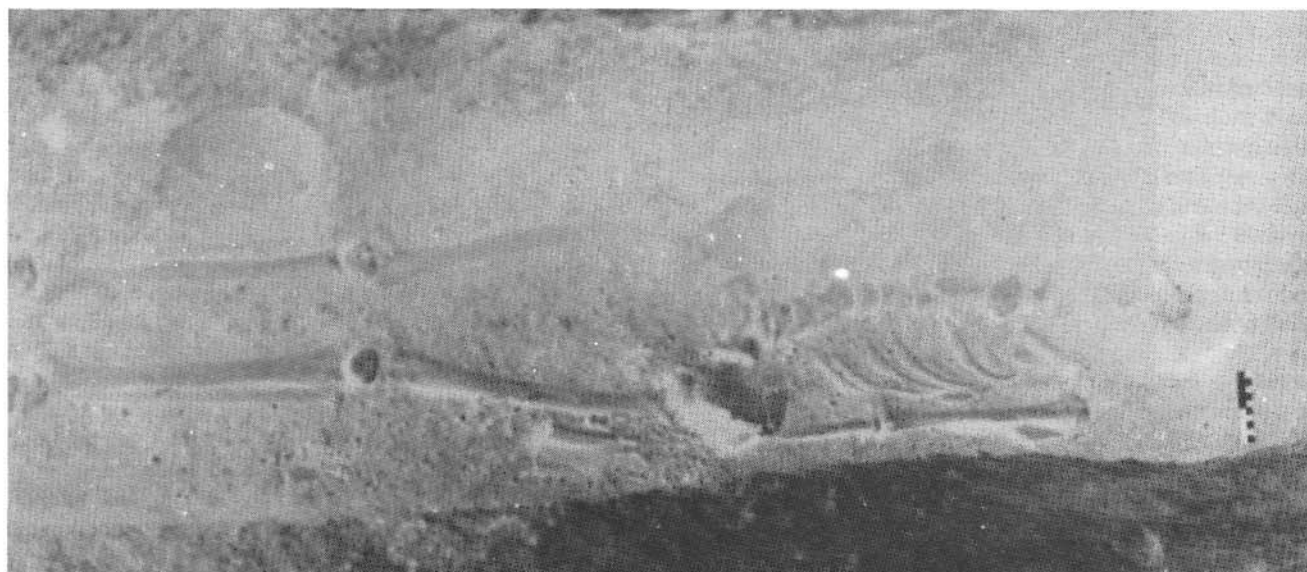
The site of Non Mak La was excavated in 1985 by a team of the Central Thailand Archaeological Project. Apparently, the mound of Non Mak La consists of both domestic and industrial areas. A ceramic assemblage from the domestic quarter of the site is quite comparable to the assemblage found at Lop Buri Artillery Camp. The seeming industrial area is a large glassy slag heap about 1 metre deep, and more than 100 square metres in area. Dr. Vincent Pigott of the University of Pennsylvania suggests that the glassy slag at this site indicates quite an efficient smelting technology. However, prills of metallic copper, the size of which varies from several mms. to less than 1 mm., are always found

trapped inside the slag. Other metallurgy-related materials including crucible fragments, tuyeres, and fragments of furnace lining are also found in the slag layer. Mr. Udom from the Department of Mineral Resources, who joined the excavation for a short period, also identified copper ores in the slag deposit. Thus, it is evident that Non Mak La represents another copper production locality of the first millennium B.C.

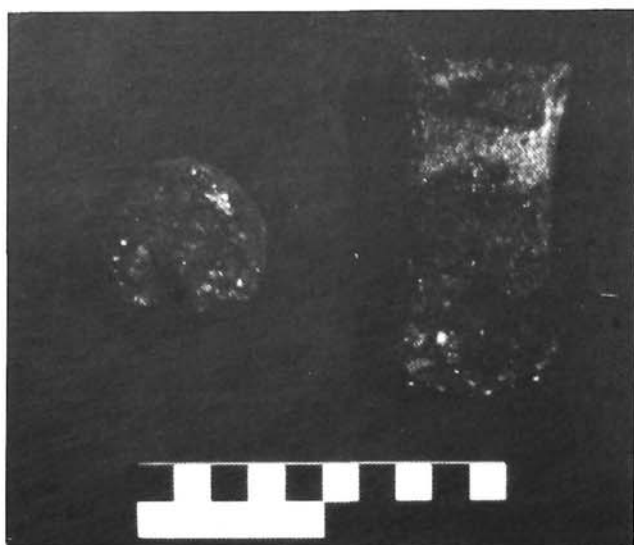
NON PA WAI, NON KHOK WA AND NIL KHAM HAENG RESERVOIR

These sites were originally surveyed by CTAP three years ago (CTAP 1984), while excavations there were undertaken in 1986 by TAP. The excavation team comprised Dr. Pigott, Mr. Andrew Weiss and Miss Lisa McQuail from the University of Pennsylvania, Dr. Roberto Ciarla from ISMEO in Rome, Mr. Udom from the Thai Department of Mineral Resources, and the writer of this article from the Fine Arts Department.

The site of Non Pa Wai appears to be the largest prehistoric copper production site so far discovered in Thailand, if not Southeast Asia. The excavation here revealed a deposit about 3 metres deep covering an area of about 5 hectares. The deposit contained a very large amount of copper metallurgy debris, potsherds, animal bones, and some burials. It can be separated into 2 major phases. The early phase yields evidence of copper smelting and some burials. One of the more interesting burials contained an extended skeleton with several broken pieces from a pair of ceramic bivalve mould (for socketed axe casting) placed at both hands and at other parts of the body. This burial is nicknamed "The Metal Worker's Grave". Another burial was furnished with a copper-based socketed axe. This axe, which could have been produced in a mould from "The



An unusual burial excavated at Non Pa Wai, Lop Buri in 1986. This particular skeleton was surrounded with several bivalve moulds for making axes. The excavators believed that this burial represents a highly-specialized master craftsman.



A copper axe at the right and a disc of hematite dug at an industrial site Non Pa Wai, Lop Buri. Below the layer where these artifacts were found were burials.

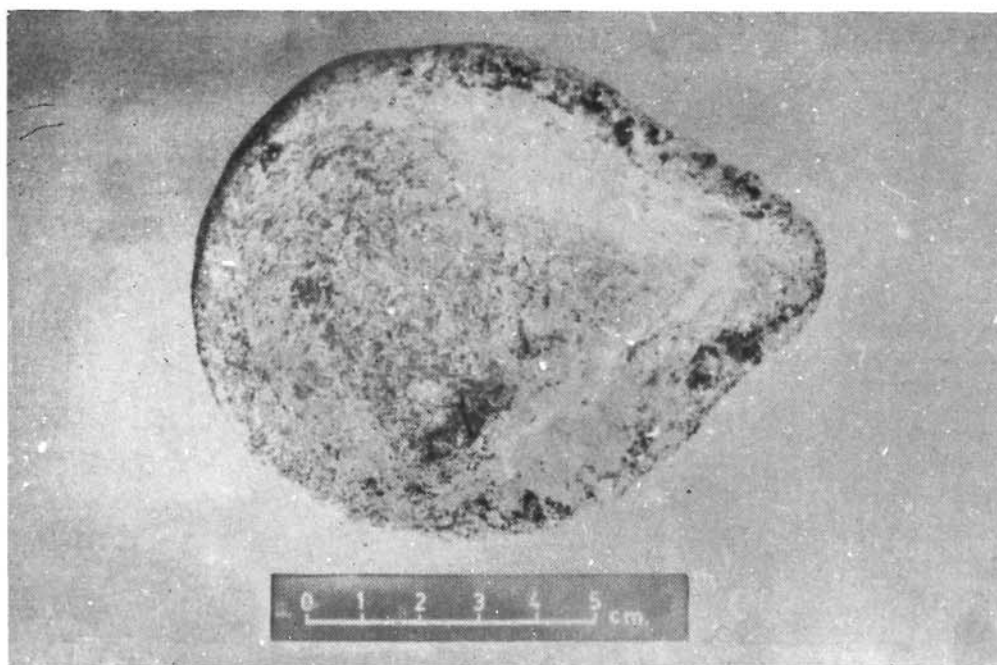
Metal Worker's Grave", has beveled sides on one face, but curving sides on the other. Faunal remains from the early phase include both aquatic and mammal species. Ceramics with coarse corded-impressions on the exterior surface predominated. These ceramics are similar in style to those from phase I of Huai Yai. They are also typologically comparable to sherds excavated from the prehistoric occupation at Sab Champa (Artit 1972; Veerapan 1979), located about 60 kilometres, northeast of Non Pa Wai. The

later phase at Non Pa Wai is represented by a deposit averaging 3 metres deep of ashy soil intermixed with copper smelting slag, ceramic moulds in cup and conical shapes, ceramic bivalve moulds, fragments of large crucibles, etc. This large volume of metallurgy debris seems to indicate a period when a boom in copper production occurred. The ceramic assemblage from the later phase, especially the cup and conical moulds and the distinctive pottery decoration styles, is clearly different from the assemblage of the basal levels. A diagnostic black and dark brown burnished pottery with triangular incised designs around the shoulders is comparable to vessels unearthed at Lop Buri Artillery Camp. This forms the basis for placing the copper production of the later phase at Non Pa Wai in the first millennium B.C.

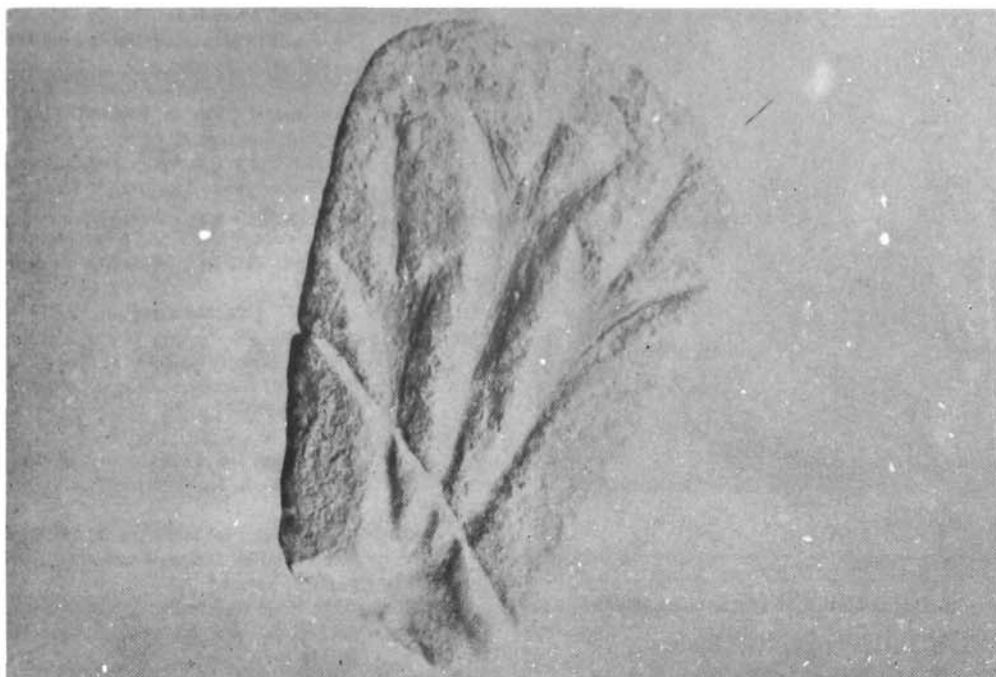
At Non Khok Wa, a small test trench was dug. It is evident that the area was a prehistoric ore crushing site. Based on ceramic comparison, the ore crushing activity at Non Khok Wa is very possibly contemporaneous with the later phase of Non Pa Wai.

The excavation at Nil Kham Haeng Reservoir revealed a deposit more than 5 metres thick, comprised numerous layers containing finely crushed ore and slag. Some ceramic bivalve moulds, small bowl-shaped copper ingots, and a few mis-cast copper implements were recovered here. The most interesting find made here was a burial with a bimetallic bracelet. This bracelet, of iron wrapped around a copper-based metal core, recalls the one reported from Ban Chiang, in levels now dated to the first millennium B.C.

The number of sites and the quantity of slag at each copper smelting site in the Lop Buri area point to an industrial level of copper production. The fact that cup and



An earthenware crucible showing traces of copper drippings excavated at Noen Klong Bamrun, Lop Buri.



Ceramic mould for making arrow heads excavated at Non Klong Bamrung, Lop Buri

conical moulds were made in several sizes suggests that various standard sizes of copper ingot were produced along with some copper objects. However, it is interesting to note that not many ingots or finished objects were found in the excavations and surveys at these sites. This may indicate that most of the metal produced at Khao Wong Prachan was distributed to other areas for working.

It has been pointed out elsewhere that intersite exchange networks were already well established during the second millennium B.C. in Central Thailand (Surapol 1984). This idea is supported by the fact that ornaments of marine shell were found at a number of sites. For example, cowries with a cut-off back were recovered at the sites of Kok Chareon, Tha Kae, Lop Buri Artillery Camp, and Noen Klong Bamrung in Central Thailand. Cowries shaped by the same technique were also unearthed in a burial at the site of Non Chai, Khon Kaen Province, northeastern Thailand. Mourer and Mourer (1970) also mentioned cowries with cut-off backs in their report on excavation at the site of Laang Spean in Cambodia.

The relationship between the Khao Wong Prachan copper production centre and other sites in Central Thailand can be tentatively reconstructed. More than 40 sites containing some artifacts relating to copper/bronze metallurgy have now been located within the Lower Chao Phya Valley. Among these, the most interesting sites include Phu Noi, Noen Klong Bamrung and Sab Champa.

Phu Noi is a prehistoric cemetery located about 30 kms. northwest of Khao Wong Prachan. Thirty-two burials were

exposed in a 3 by 5 metre test trench. Other than pottery, some skeletons were furnished with ornaments of marine shell, turtle carapace, ivory and non-local stone beads. These finds are strong evidence for the existence of exchange networks linking Phu Noi with other sites in the interior and on the coast. Contact between Phu Noi and the Khao Wong Prachan copper production centre can be deduced from a clay mould, of the same fabric as those found at Khao Wong Prachan sites, and a copper/bronze bracelet recovered accidentally by a villager during construction of a new monastery at Phu Noi.

The site of Noen Klong Bamrung was excavated by Miss Saengchan Trikasem of National Museum Division, Fine Arts Department. It is located about 60 kms., northeast of Khao Wong Prachan. The excavator found a cemetery with a number of burials containing copper/bronze artifacts. The most interesting find there was a burial with clay bivalve moulds. The writer of this article has already examined these moulds and found that they have the same fabric and form characteristics as moulds from the copper production sites in the Khao Wong Prachan Valley.

The site of Sab Champa, situated about 60 kms. northeast of Khao Wong Prachan, was excavated by a team from Silpakorn University led by Veeraphan Malaiphan (1979), who reported that a number of ceramic bivalve moulds were unearthed. Sab Champa was briefly revisited in 1984 by a team of the CTAP; they found that a local villager had collected several bivalve moulds that resembled those from the Khao Wong Prachan area.



Copper or bronze axe dug at Noen Klong Bamrung, Lop Buri.

CONCLUDING REMARKS

The evidence excavated from these prehistoric copper-based metallurgical sites is still being analyzed. When this work is finished we can expect a better understanding of the history of copper/bronze metallurgy in Thailand and Southeast Asia.

At this moment the writer of this article is convinced that copper-based metallurgy was well developed in mainland Southeast Asia by the second millennium B.C., if not earlier.

It is hoped that the results from the current analyses will make it possible in the near future for the undertaking of problem-oriented research, designed to deal specifically with the causes and consequences of the adoption of copper-based metallurgical technology. Thus, a better understanding of cultural processes in prehistoric Southeast Asia may eventually be reached.

ACKNOWLEDGEMENTS

The writer of this article would like to extend his appreciation to the staff members of the Research Section, Archaeology Division for their assistance in preparing and typing this paper. Special thanks is due to Dr. Bennet Bronson who proof read this paper and provided some valuable suggestions.

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