

THE BEGINNING OF BRONZE TECHNOLOGY IN EAST ASIA

by

MARY Verna STARK
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Department of Anthropology and Sociology

The University of British Columbia
2075 Wesbrook Place
Vancouver, Canada
V6T 1W5

Date May, 1976

ABSTRACT

The purpose of this thesis is to review the English language material concerning the beginning of bronze technology in East Asia in order to evaluate the evidence for the birth of bronze metallurgy in East Asia.

The method of investigation was first to study published and unpublished material on North, Central and South East Asia. This study included the history of research under the categories of method, theory, and chronology of archaeological investigations, and hypotheses on origins and routes of bronze technology in East Asia.

The examination of bronze metallurgy followed. This comprised the ramifications of the occurrence of copper-working, the production and analysis of the alloy bronze, the method of production of bronze objects, the dating of bronze artifacts and the social context of bronze production.

The next step in the study was to explore the Neolithic stages of culture in the diverse areas in order to examine the precursors of bronze-producing societies and to determine the earliest bronze assemblages.

The earliest bronze assemblages were in turn investigated. The metal objects, both copper and bronze, in these assemblages were tabulated and compared chronologically. The categories of metal objects were used to illustrate the relative sociocultural integration of each bronze producing group. Evidence of casting of the metal in the assemblages was compared to ascertain the similarities, if any, among production procedures.

Chemical analyses of the bronze in the assemblages were tabulated for comparison and examination of relationships.

Finally, similar types of artifacts in the assemblages were tabulated for stylistic comparison.

The general conclusions from these investigations are that the four assemblages of earliest bronze technology in East Asia are from Minusinsk in southern Siberia, Erh-li-t'ou in North China, Ta-p'o-na in southwest China and Non Nok Tha in northeastern Thailand. Of these assemblages, neither Minusinsk nor Ta-p'o-na demonstrated the beginning of bronze production.

The archaeological evidence does not establish the beginning of bronze metallurgy as being shown at either Erh-li-t'ou or at Non Nok Tha but the possibility exists for either indigenous development from external stimulus or separate invention with no outside stimulus of any kind for either area.

This study has demonstrated the existence of different technologies, different levels of social integration and different social contexts for bronze in all four early assemblages. Thus it has also demonstrated that the beginning of bronze production did not have to occur in urban or state environments.

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INTRODUCTION

The aim in this thesis is to review the English language material concerning the beginning of bronze technology in East Asia -- North, Central, South -- and to examine various hypotheses concerning the origin of this technology in the various regions. To accomplish this it will be necessary to review chronologically hypotheses based on archaeological excavations in Siberia to the east of the Yenisei River, in China and in Southeast Asia.

History of Research

Some of the trends of East Asian archaeology beginning in the late 1800's are the establishment of a scientific discipline of field archaeology, the tentative grouping of cultures in the diverse regions, the establishment of stratigraphy as the principle of chronology, the use of typological comparison as the basic tool for the reconstruction of past sequences and past relationships, the prevalence of diffusionist theories, and the use of migration to explain variations in cultures. Since then, the methods and theories used to excavate and report materials from sites have changed. Bone, plain pottery and vegetable remains have all become as important as the more "exotic" artifacts in the excavation methods thus giving further insight into the food sources, the climate and the stage of development of the cultures. Carbon 14, dendrochronology, thermoluminescence and archaeomagnetic dating methods and modern micro-techniques of analysis of ancient metals, have given further

insight into the ages of various sites and cultures. The new archaeological theories on sites and on site comparisons -- viewing culture as a system with subsystems and the importance of the delineation of causes and effects in the variability of the cultures -- have necessitated a more rigorous approach to the hypothesized relationships of the diverse cultures to one another. This progression in the method and theory in archaeology is evident in the published literature on East Asia, notably in Bayard's (1972: 1411-1412) report on Non Nok Tha, based on electron probe analysis of the earliest metal found at the site, substantiated by carbon 14 and thermoluminescence dates.

Archaeological research in East Asia began in various regions at different times and progressed at different rates. Systematic studies in the Soviet Far East in the Amur River Valley began in 1954; although earlier work had been done by individuals in 1855 and from 1899 to 1932, and by an expedition under Okladnikov in 1935 (Derevianko 1965: 136). In Southern Siberia, in the upper Yenisei River area some work was done in the 1880's by J.T. Savenko (Maringer 1950: 3); in other areas of Siberia research began around 1930.

Although Korean archaeological study started in the early 1900's and excavations started in the 1920's no large scale work using acceptable standards of research and methodology has been undertaken yet (Kim Won-yong 1975: 61-62).

In Japan extensive and intensive archaeological work dates back to 1879 (Chard 1974: 3).

The Tungpei region has had very few sites investigated extensively. For the most part, surveys and site sampling only have been carried out (Chard 1974: 106).

In Mongolia, the eastern border research was started in 1906 by R. Torii but the era of intensive research and major discoveries began about 1920 -- Andersson 1921 in Jehol, Licent and Teilhard de Chardin 1922 and 1924 in Jehol, the Andrews Expedition 1922-1930 mainly in Outer Mongolia, Licent and Teilhard de Chardin 1923 in the Ordos, and the Sino-Swedish Expedition 1927-1935 in Inner Mongolia (Maringer 1950: 3).

In China scientific archaeology began in 1920 with Licent and Teilhard de Chardin and Andersson, but because of wars, rebellions and revolutions, was repeatedly slowed down or halted until after 1949, with another slowdown in the 1960's (Chang 1968: 5-6, 11-12).

Archaeology in Vietnam is dated from the early 1900's and intensified by the 1960's (Pearson 1962: 35; Saurin 1969: 27). Cambodian archaeology started around 1875 and developed especially after World War II (Mourer 1971: 35; Saurin 1969: 27). The first excavations in Thailand were by Sarasin in 1933 and expansion of research began in 1960 (Heekeren 1967: 13, 17).

The relative paucity of excavations, plus heavy reliance on diffusionist and migration theories, were responsible for the earlier beliefs that bronze technology in East Asia must have been imported from the Near East and Europe (Solheim 1967: 896) where "classical bronzes" of early date had been known for many years. These beliefs were reinforced

by the excavations at Anyang, northern Honan, from 1928 to 1939 (Chang 1968: 10), which exposed superior cast bronze objects with no evidence of a prior rudimentary technology. However, subsequent excavations at Yen-shih, northwestern Honan in 1958 to 1964, and at Cheng-Chou, central Honan from 1950 to 1959, revealed evidence of foundries, such as crucibles and molds, and of bronze technology at an earlier stage, which resulted in the speculation that bronze technology may have originated in China. Thus the majority of archaeological researchers have intensified the search for the origin and the interrelationship of bronze technology in East Asia. This has resulted in an increase in archaeological excavations and reports and an increase in the use of the natural sciences for the interpretation of the data (Bayard 1972: 1411-1412) and also resulted in a flood of conflicting hypotheses as to the origins and the routes of bronze technology in East Asia.

Hypotheses on Origins and Routes of Bronze Technology in East Asia

Okladnikov (1959: 23), Chard (1974: 145-148), Jettmar (1950: 86, 113) and Sulimirski (1970: 261, 280-281, 286, 300) theorize that the earliest bronze assemblage in the Eastern Siberian Minusinsk Basin resulted from the introduction of the stock breeding subsistence economy and metal production from the West, from areas such as the Urals and the Kazakhstan Steppes.

Barnard (1972: vi; 1967: 186, 203) and Cheng Te-k'un (1973: 208) conclude that bronze metallurgy was an independent invention in China.

Chang (1973: 528; 1975: 1969) hypothesizes that during the early Neolithic there was cultural interaction between North China and Southeast Asia and although he states (1968: 182-183) that cultural movements from the Iran/Iraq area to North China were insignificant, the Neolithic micro-lithic assemblages of Northwest China seem to resemble the microblade assemblages of Western Siberia; Chang does not commit himself as to the geographic origin of metallurgy (Chang 1963: 44; 1975: 169). Bayard theorizes (1975: 167-168) that stimuli from South China to North China started prior to the Early Neolithic and continued through the later stages of the Neolithic and that the early bronze in Southwest China was the result of another south-to-north pattern of stimulus from Thailand and Vietnam. Solheim (1973: 25-29) proposes that South China culturally was part of both Southeast Asian and Chinese cultures and that possibly one or more of the cultures of South China was the primary ancestor of all Chinese culture from the Neolithic to the metallic Shang.

Solheim (1969: 136-137) hypothesizes that the Dongs'on culture in North Vietnam dated to about 300 B.C. (Solheim 1967: 899) was a late manifestation of the earlier bronze technology seen in northeastern Thailand, combining foreign design elements from as far away as the Mediterranean with old Southeast Asian elements (Solheim 1967: 902). Boriskovsky (1966: 84-85) postulates that the Dongs'on bronze culture was local and developed out of the main Neolithic culture in Vietnam. However, Pearson's (1962: 44-45) hypothesis is that from the Late Neolithic period onward, South China and North Indochina was a single culture area and that the Dongs'on culture was formed from cultural contact from Central China.

Solheim (1974) speculates that metallurgy was invented somewhere in Southeast Asia around 4,000 B.C. and that there was little evidence of outside influence until sometime during the first half of the first millennium B.C. (Solheim 1969: 137). Thus the development of metallurgy in Thailand is unrelated to development of metallurgy in India and the Middle East (Solheim 1974: 41; 1968: 62). The hypothesis of Bayard (1970: 139) is that it appears possible that a separate invention of metallurgy may have developed in Southeast Asia independently of stimulus from either China or the Indus and earlier than in either area. The culture in Western Central Thailand has been postulated by Sørensen and Hatting (1967: 147) as the result of migration c 1800 B.C. from the Proto-Lungshan phase of the Neolithic in Central China, with later c 1500 B.C. influences from the Lungshan culture proper in China; this culture then is theorized as the foundation of the later bronze culture in this area of Thailand.

These hypotheses can only be accurately tested and new hypotheses made by further archaeological research in East Asia and by interpreting the evidence in the light of evidence found by further archaeological research in other areas as far away as the Black Sea regions.

Method of Presentation

It is my intention in this thesis to discuss the technical and social aspects of bronze metallurgy, to explore the Neolithic or Late Neolithic stage of culture in the various areas indicated earlier in order

to determine the cultural connections and levels of development up to the appearance of bronze in East Asia, and to tabulate the artifacts comprising the assemblages and compare them and make a stylistic comparison between similar types of artifacts in the assemblages. Conclusions will be drawn on the basis of an examination of this data.

CHAPTER ONE

BRONZE METALLURGY

Copper-working is the earliest branch of metallurgy (Smith 1967: 28; Young 1970: 85; Coghlan 1951: 12-13; Cushing 1967: 62,63); copper (Cu) occurs in the metallic state in nature and the earliest metal objects would have been copper hammered into shape. The melting of native copper would have been the next metallurgical step, followed by the simple smelting of copper oxide ores, found in open deposits, to produce copper (Coghlan 1951: 14; Barnard 1961: 178). Coghlan (1951: 15) suggests that the oxide ores were the first ores to be worked for they would have been available by simple collection or open-pit working and without the necessity of true mining; a further advantage is that they may be reduced to copper by a simple process of direct smelting in a primitive furnace using charcoal as fuel; the sulphide ores require deep mining and the process of reduction is a difficult one. After copper smelting the important discovery was that of the harder copper-tin alloy, bronze. Copper with natural impurities from selected ores was an important introduction to the advantages of alloys; for example, copper with a low percentage of antimony and/or arsenic is easier to melt, gives sounder castings and is mechanically stronger and harder than pure copper; the advantages of impure copper may have been recognized and deliberately chosen as the bright colours of the different ores were obvious (Smith 1967: 31; Lambers-Karlovsy: 1967: 151). Tin (Sn) is less plentiful than copper (Charles 1975: 19) and does not occur in the natural state but it

is found in veins and in alluvial sands and gravels as tin oxide (cassiterite); tin is made by a simple process of direct reduction by heating the oxide in a charcoal fire (Coghlan 1951: 16-17). Some tin ores contain impurities of copper, iron, lead, antimony, bismuth, sulphur and arsenic; these impurities tend to make tin harder and less malleable. Oxide ores of copper only require a temperature between 700° and 800° C for their reduction to metallic copper; copper melts at 1083° C (Coghlan 1951: 21-23; Dougherty and Caldwell 1966: 984). Steinberg (1970: 115) lists examples of the changing melting points of bronze alloys with the diverse constituents as follows:

TABLE I. CHANGING MELTING POINTS OF BRONZE ALLOYS.

Alloy given by Weight Percent			Melting Point $^{\circ}$ C
Copper	Tin	Lead	
93	7	0	1050
92.6	6.4	1	1035
91.7	6.3	2.0	1025
88.9	6.1	5.0	1015
82.4	6.6	11.0	980
73	5.0	22.0	950
84	16	0	950

The temperature required for pottery kilns would be more than adequate for bronze production (Coghlan 1951: 21-23; Barnard 1961: 59). Watson (1971: 67, 70) states that Early Neolithic period pottery was fired between 950° C and 1050° C, while Cheng Te-k'un (1973: 207) gives the temperatures for this pottery period as 1300-1400 $^{\circ}$ C.

Long before bronze came into general use, marked inclusions of tin in the copper are found in many prehistoric implements. These are the

"accidental" bronzes which occurred many times prehistorically when the "enriched" ores, in which tin was associated with copper, were used -- the bronze produced contained 3% or less tin. "True" bronze is defined as a copper-tin alloy in which the tin content is in excess of approximately 3% (Coghlan 1951: 21-23). Wheatley (1971: 72) states the customary connotation of bronze is restricted to an alloy with 5-20% tin in copper. Lead (Pb) in copper or bronze casting produces cleaner castings, improved colour and gives greater facility in machining (Coghlan 1951: 21-23; Barnard 1961: 49; Smith 1967: 22, 1970: 56). It has been concluded that the outstanding properties of bronze were probably discovered first from melting naturally occurring mixed ores, and later by alloying separately smelted metals (Coghlan 1951: 24; Smith 1967: 31; Cushing 1967: 64). In casting, bronze is superior to all other metals; as bronze solidifies it also expands, forcing the metal into every crevice of the mold, then in cooling it contracts slightly, making removal from the mold easier (Savage 1968: 17).

There are a variety of molds that can be used in the casting of bronze objects; single or two-piece (double or bi-valve) molds; composite molds for producing more than one object at a time; molds with the addition of cores; simple piece molds and multi-piece molds. The less complex molds, with one direct pour casting, were usually used by the earliest practitioners of metallurgy.

Cire-perdue, the lost wax process, and the sectional mold process are the two main methods for casting bronze (Barnard 1961: 86; Young 1970: 187).

Awareness of these diverse points in bronze metallurgy can help the scholar make decisions about the origins and the relative age of bronze objects.

The internal structure of a metal object can often throw more light on its origin than a stylistic analysis (Smith 1967: 51). Information on the structure of bronze specimens may be obtained by a variety of methods. Optical spectro-chemical analysis has been widely used for over thirty years; initially a sample was electrically burned and produced characteristic light waves of all elements present. The recent invention of the optical laser microprobe permits direct sampling of the object, removing a sample only 50 to 80 microns in diameter with an average depth of 80 to 100 microns, also producing an optical emission spectrum (Young 1970: 93-94). Emission spectrography with an inherent accuracy of only circa 10% to 15% may be sufficient in some cases but if an accuracy of circa 1% is required, then methods such as polarographic and atomic absorption analysis must be employed; this accuracy may be necessary for such a precise problem as establishing a correlation between a given pattern of trace impurities and a particular source of the constituent area (Werner 1970: 180, 184). The solid state x-ray detector like the spectrograph utilizes the spectrum, but it has the added advantages of rapid chemical analysis from selected areas of the object, without damage to the object, and it also provides information in the technique of fabrication and the thermal treatments used in production (Ogilvie 1970: 87). The metallurgical microscope can also be utilized for determining how an object was produced and for authentication of the object (Young 1970: 91-92).

Caley (1967: 167-171; 1970: 37-38) warns that over half of the published analyses of ancient metals are defective in some way; when size and weight of samples are not given it may affect the analytical conclusions; often impurities are not determined thus giving an inconclusive analysis; different cleaning methods used for the sample or samples may affect the analysis differently and if they are used the method should be stated; the method of analysis is often not reported. Slater and Charles (1973: 221) also warn of the danger of basing an analysis on single small samples which may give nonrepresentative results. Chemical composition figures for bronze artifacts can show variation depending on the particular laboratory which carries out the tests. Chase (1974: 148) found relative deviation ranges of 4% for copper up to over 200% for some trace elements when he sent 500 mg. samples of two bronzes (one of which was Chinese) to 21 laboratories asking them to test for 48 elements. Barnard (1972: 21) found similar discrepancies. There is a necessity for more scientific analyses and publication before laboratory results on bronze can be used effectively and with confidence by scholars. It is also obvious that there is a general dearth of this type of analysis for most archaeological bronzes.

The dating of artifacts, especially bronze, is of utmost necessity for attempting to establish the beginning of bronze metallurgy in any given area. Radiocarbon (carbon 14, C 14) dating has been the main dating technique used since its initial introduction by Libby in 1949, using the half-life of carbon-14 at 5568 ± 30 years and the present, before which these dates occur, as 1950. More recent and presumably more accurate

physical half-life values of 5730 ± 40 years are available but the original Libby values are retained by Western scholars to ensure uniformity and to avoid the confusion of adapting each new value of the half-life as it becomes available (Libby 1970: 8; Pearson 1973: 141; Barker 1970: 38). However, it has been found that C 14 dating for absolute dates can be incorrect by as much as 600 or 700 years at the peak of the deviation, some 7000 years ago (Libby 1970: 7). The deviation back to 7500 years ago can be determined and chronology can be extended back to agreement at 10,000 or 11,000 years ago by the Bristlecone Pine calibration assessments (Libby 1970: 7-9; Barker 1970: 38; Barnard 1972: 12-14). Barnard (1972: 11, 31) suggests that future conversions of radiocarbon dates may be effected far more conveniently into dendrochronological calendar years with reference to the table of Damon, Long and Wallick, published in 1972. However the 8th International Conference on Radiocarbon Dating decided that no particular calibration curve or table should be adopted at present (Burleigh 1973: 55).

At present C 14 dating is somewhat more accurate than thermoluminescence dating, however, thermoluminescence dating has the advantage of dating an actual activity of man, and the sherd samples necessary are abundant on most sites (Aitken 1970: 83; Bronson and Han 1972: 325). Precise dating can be attempted only if appreciable knowledge of the burial conditions of the pottery is known and if some damage to a complete object is undertaken (Fleming 1970: 207-208). Nevertheless, thermoluminescence dating methods could be valuable in the dating of clay cores still existing in a bronze casting (Barnard 1967: 185), as could an archaeomagnetic dating method be useful for dating baked clay in situ (Aitken 1970: 80).

Apart from these technical aspects of metallurgy there is the social context of the occurrence of bronze.

With respect to the social aspects of bronze metallurgy one of the questions that arises is what sort of organization is necessary for the production of metalwork. Of particular importance to the answer for this question would be evidence of subsistence economy, settlement pattern, technology, sources of raw material and trade; in other words, metalwork is only a subsystem within the larger cultural system and cannot be studied in isolation. Furthermore it is itself composed of a number of socioeconomic activities. It is often difficult to obtain this evidence from archaeological investigation, particularly in the areas of sources of raw materials and trade. Rowlands (1971: 210-224), basing archaeological interpretations of prehistoric metalworking on ethnographic examples, divides metalworking, as a separate cultural institution, into a number of socio-economic activities including the organization necessary for the production of metalwork. A considerable variation occurs in the earliest industrial organization of metalworkers depending on the specific cultural beliefs for the organization of the kinship/descent groups, which are the groups organized for metalworking and serving small centers of population. The form of organization is clearly influenced by the settlement pattern, population density and economy, although metalworking can appear at the subsistence level of economy. A dispersed settlement pattern made up of small autonomous or semi-autonomous units, such as hamlets or villages, tends to encourage a

dispersed craft organization and the presence of small occupation groups (ibid.: 217-218).

Production, resulting from part-time or full-time specialists, occurs in relation to variations in many variables, such as size and complexity of the community and degrees of economic interdependence in the community but increased production is not necessarily accompanied by major changes in settlement size or socio-political organization (ibid.: 219).

The status of the smith varies from low to high according to the various beliefs of the different cultures and according to the precise objects that the smith produces; the importance of the smith for supplying tools and weapons to the community is a source of influence that can be politically exploited as in the Northern Chin tribes of Burma where the smiths are village officials (ibid.: 217).

There are many ethnographic examples of the smith only contributing his skill to production while the customer supplies the raw material and/or fuel and/or labour; one instance from the Congo showed the smith working in iron, brass and copper which was supplied by the customer who obtained it either from the smelter or by exchange (Rowlands 1971: 211). The trade of raw materials and finished products need not be the result of specialized trade networks or long-distance trade routes.

The spatial distribution of the area of primary exchange between the smith and his customers may be extensive, intravillage and/or inter-village, but is of course limited by actual contact between them, however, the spatial distribution of the metal objects themselves may be much more

extensive, for example the demand for a superior quality of metal objects resulting from superior ores which are located in one area only. In some instances, metal objects, as they move farther away from their point of origin, lose their functional value and become valuable as raw material only (ibid.: 219-220).

CHAPTER TWO

NEOLITHIC TO BRONZE TECHNOLOGY

It is imperative to explore the Neolithic cultures of East Asia to determine their cultural connections and levels of development in order to ascertain where the earliest bronze assemblages occurred and whether these assemblages could have been the result of indigenous development or the result of external stimuli.

A number of widely divergent Neolithic cultures, occurring in very different ecosystems, can be seen in the area under study.

Siberia

The term "Neolithic" to Russian, Korean and some Japanese archaeologists indicates simply the presence of polished stone and pottery present in the culture, whereas to other archaeologists the "Neolithic" means food production, usually accompanied by polished stone, ceramics, domestication of animals, a more sedentary life, some part-time specialists and a proliferation of material culture with luxury goods. Chard (1956: 406) uses the term to denote all remains that seem to antedate actual knowledge of metal working, with no other connotations implied, when referring to the northeast portion of Siberia from the lower Lena River basin to the east, and he restates this again (Chard 1974: 63) in reference to Northeast Asia, when he says the "Neolithic" refers to that stage of cultural development in each area from the first appearance of pottery to the establishment of an effective metallurgy -- or to the time of historic contact in those areas which did not adopt metal working."

The northeastern-most areas of Siberia during the Neolithic stage had hunting and fishing, semisedentary population, and ceramics and had cultural affinities with the Baikal-Angara region at the headwaters of the Lena River but none with the Pacific Coastal Area (Chard 1956: 406-407).

Along the Soviet Maritime Coast in the Amur River Valley, especially in the Middle Amur and in the area around Vladivostok, there were well-developed hunting, gathering and river fishing practices or incipient agriculture with some stable settlements and ceramics. There was a pronounced diversity to the Neolithic cultures as a result of active contact between indigenous populations and other groups as far away as Yakutia, the Baikal taiga, Tungpei, Korea and Japan (Derevianko 1965: 139-140; Chard 1974: 90; Chang 1968: 183). Okladnikov (1959: 15-17) basically agrees to these facts but he adds North China specifically to the contact areas and he also states that in the Soviet Maritime Region were maritime fishers, who maintained sedentary occupations of the area. Chard (1974: 93) concludes that the Amur Valley and the Maritime Territory had a substantial continuity from Neolithic to historic times in the pattern of life; there is no mention of the presence of bronze.

Interior Siberian Neolithic, as shown in Yakutia in the Middle Lena River area to the Arctic, is represented by hunters and fishers who possessed pottery. There is much continuity from the Early Neolithic in stone and bone-working technology, but with considerable additions seemingly borrowed from many directions (Chard 1974: 65; Okladnikov 1959: 32). There

was no essential change in the culture with the first appearance in the mid-second millenium B.C. of objects of copper and bronze or the eventual local bronze casting on a small scale (Chard 1974: 74).

The Neolithic of the Lake Baikal forest region on the Angara River, another regional manifestation, was influenced by areas in the west and on the Yenisei River, in Trans-Baikal and as far as Inner Mongolia during the Serevo-Kitoi stages (third millenium to beginning of second millenium) according to Michael (1958: 33); Neolithic culture here was characterized by a hunting and fishing economy with permanent settlements and pottery. The appearance of small amounts of copper and bronze during the Glaskovo period, 18th-13th centuries B.C., brought no fundamental changes in the culture (Chard 1974: 77; Michael 1958: 33). Chard (1974: 145, 207-208) concludes that with only a few useful additions from outside, such as pottery, ground stone artifacts and metal, the patterns of adaptations to taiga environment persisted in much of the forest zone of Siberia until relatively recent times. Only on the southern steppe did new economic patterns eventually take hold. Larichev (1962: 93-95) states that in Cis-Baikal, on the Angara River, settlements around Buret, although occupied continuously, had two markedly different periods of occupation -- Neolithic and Bronze Age. The Neolithic settlement was a comparatively permanent settlement with a large population possessing pottery, stone tools, and a hunting-fishing subsistence pattern and with cultural-ethnic relationships to the populations of Central Asia and Northwest China (*ibid.*: 93). The Bronze Age settlement period shows a marked change, mainly represented by locations of short term settlements or

stopping places; however Larichev (ibid.: 95) states that at certain sites "foundries of various sorts appear" but he gives no supporting evidence. These changes were brought about by the establishment of closer connections among Cis-Baikal and the Trans-Baikal, Minusinsk Basin, Mongolia and Tungpei (ibid.: 95). Bronze technology then, did not originate in the area of the Angara River but came from the Minusinsk area.

The Minusinsk Basin, an island of steppe on the upper Yenisei River surrounded by forested mountains, west of Lake Baikal, was the first area of food production, brought from the West by Europeans with the Afanasiev culture at the end of the third millenium or beginning of the second millenium B.C. (Okladnikov 1959: 22-23). This subsistence economy, which mingled with the Neolithic hunting culture, included stock breeding as well as hunting; farming is suspected. Stone and bone technology was still predominant but some copper products appeared, primitive in form (Chard 1974: 145; Okladnikov 1959: 22). A special development in this area of Minusinsk and the Altai occurred when an alien group from the adjacent forest zone supplanted the Afanasiev culture with the Okunev culture, taking over the domestication of animals and practicing a rudimentary bronze technology and also producing rich animal and human art forms on bone and stone (Gryaznov 1969: 39, 51; Chard 1974: 145,148). Metallurgy (copper, bronze, tin, gold) became well established in the succeeding agricultural Andronovo culture c. 1500-1200 B.C. in Minusinsk and in the Altai, which represented the eastern half of a belt of similar culture and peoples extending from the Don River to the Yenisei River (Chard 1974: 145, 148; Okladnikov 1959: 23; Sulimirski 1970: 100). The

Afanasiev pottery shows strong similarity in form and decoration to Kel'ti-minar pottery from the region of the Aral Sea and burial ornaments include shells which could only have been obtained from the Aral Sea. Skeletons from Afanasiev burials were of European racial type not of the Mongoloid type found elsewhere in Eastern Siberia (Chard 1974: 145; Okladnikov 1959: 23-24; Jettmar 1950: 133). Andronov^o sites with similar pottery, metal objects, and skeletons of Europoid racial type were found in the Urals, in the Kazakhstan steppes and in the Altai and Minusinsk (Okladnikov 1959: 23-25). The copper industry, using molds, occurred in the Urals about 1900-1700 B.C. with a development of north Caucasian types of tools and the tin-bronze industry had already appeared in the south Urals, the lower Volga area and West Siberia by the fifteenth century B.C. with the production of socketed lanceheads, axes and flat knives. The beginning of the Siberian mining and bronze industry was modest and its roots lay in the west as shown (Figure 1:1) by the earliest of bronze products, flat knives, which are of North Caucasian type.

The forest steppe and steppe territory of the Trans-Baikal region east of Lake Baikal show cultural links in subsistence, tool types and pottery, with the Lena River, northern Tungpei, Mongolia (Maringer 1950: 205-208) and the Baikal Neolithic; Chinese influence is not discernable in Trans-Baikal during the Neolithic and its influence in the Bronze Age may be indirectly from western Tungpei (Chard 1974: 77, 82). The first evidence of food producers in the Trans-Baikal and northern Mongolia are stock-raising, horse riding nomads dating from sometime in the first

millennium B.C.; there is no trace of farming. The Trans-Baikal region and northern Mongolia became the focus of a well developed metallurgy with its own features sometime in the first millennium B.C. (Chard 1974: 163-165). At this relatively later time the local Mongoloid population received direct influence from the Shang people of China as revealed by the presence of pottery li tripods (Chard 1974: 165; Okladnikov 1959: 47). Continued strengthening relations with the Minusinsk Basin, the Altai, Central Asia and the Scythian tribes of the Black Sea are reflected in the bronze weapons, decorations and art objects (Okladnikov 1959: 47).

Mongolia

As already noted Northern Mongolia (Outer Mongolia) is part of the Trans-Baikal steppe culture. Chard (1974: 62) and Maringer (1950: 206; 1963: 80) establish similarities in Neolithic tool types between Inner Mongolia and South Siberia and Maringer states that the economy was hunting and fishing, as was the case in Trans-Baikal. However Late Neolithic Inner Mongolia was influenced by painted pottery and some axe types from Neolithic China according to Maringer (1963: 81). Chard (1974: 160) agrees with Maringer, however, he postulates that there was agriculture which was later replaced by the steppe nomad pattern. Maringer (1950: 207) denies the existence of agriculture but also remarks (Maringer 1963: 80) that this statement was not conclusive for every area. Any bronze objects found were from a later or a different culture (Maringer 1950: 13, 22, 34, 93, 208), with China being suggested as the influencing culture (Maringer 1963: 82). All the hunting and gathering Neolithic

populations on the southern fringes of Inner Mongolia, including the Ordos and southern Tungpei, with steppe vegetation were influenced by contacts with North China (Chang 1968: 162-166, 182; Chard 1974: 61, 105, 166).

Tungpei

Tungpei was an area of cultural overlap showing varying degrees of Chinese influence; the hunting, fishing, gathering population was influenced in the south, as noted, by Neolithic Chinese farmers, and as a result probably had farming at an early stage. It is presumed that the northern area was influenced by the Siberian Maritime area, the western area was influenced by the Mongolian steppe and the eastern area by Korea (Chard 1974: 105-107; Chang 1968: 166-168, 183, 351). The metal age appeared with increasing and spreading Chinese influence in the regions suitable for farming (Chard 1974: 107; Chang 1968: 353).

Korea

The Korean peninsula was also an area of cultural overlap during the Late Neolithic (c 1500-500 B.C.) with the northeast area being part of the Siberian Maritime Coast culture area; the northwest had close links with Tungpei which was related to the North China cultures; the south had contacts with Japan. Their economy was mainly fishing and shell collecting but included hunting and farming. The appearance of bronze was accompanied by the emergence of several new burial forms and the postulated appearance of more developed agriculture; it was introduced by

Tungus people from Tungpei and was influenced by Siberia, Mongolia and Tungpei (Chard 1974: 103-104; Kim Won-yong 1975: 103-104; Pearson 1975: 7; Kim Jeong-hak 1972: 167; Chang 1968: 183; Kim Jung-bae 1975: 174).

Maritime Northeast Asia

The culture of the coasts and islands of the North Pacific coast down to Japan were oriented toward the sea. The prehistoric coastal areas are largely unknown but in the Chukchi Peninsula and in Kamchatka a fully developed Neolithic was present around the first millennium B.C. with pottery, ground stone and fishing subsistence economy in Kamchatka and fishing and reindeer hunting economy in the Chukchi Peninsula (Chard 1961: 213; 1974: 101-102).

The Island of Sakhalin was populated by the Neolithic population of the Amur River who continued to be sedentary, hunting, river-fishing, gathering people until the final centuries B.C. and first few centuries A.D. At this time in South Sakhalin a full-fledged maritime culture was introduced, possibly from the Bering Sea area, and merged with the local Neolithic culture before expanding to the northwestern tip of Hokkaido and eventually up into the Kurile Islands (Chard 1961: 213-216, 1974: 99-100). At the end of the Neolithic metal could have been introduced into western and southern Sakhalin from the Maritime Territory of Siberia and Northern Korea, or artifacts made with metal could have been obtained from Hokkaido (Yoshizaki 1963: 145).

Japan

The Neolithic Jomon culture of Japan consisted of hunting, fishing, gathering cultures possessing pottery; the Pacific coast of northeast Honshu in Late Jomon had a maritime culture. In western Japan, where rice farming, new pottery styles and metal were first introduced, the Jomon ended about 400 B.C.; elsewhere in northern Japan it persisted longer (Chard 1974: 114, 131; Izumi 1961: 1). The succeeding Early Yayoi culture of Japan is a mixture of indigenous Jomon and continentally-introduced cultural elements such as paddy rice cultivation, new polished stone tool types, and some burial types such as the dolmen in addition to weaving and metallurgy. The appearance of continental bronze goods did not occur until the Middle Yayoi stage (c 100 B.C. - 100 A.D. -- on the basis of associated ceramic types); continued and close contact between Kyushu and Korea is very apparent at the beginning of this stage (Chard 1967: 11; 1974: 169-175; Kidder 1959: 90-91; Befu 1965: 42; Kaneko 1964: 26-33; Bleed 1972: 2-8).

The Ryukyu Islands

The Neolithic in the Ryukyus (c 1500 B.C. to 800 A.D.) had an economy of hunting and shell collecting; the presence of agriculture has not been verified; pottery and polished stone tools were present. There appears to be a connection with the Late Yayoi period of Japan. Metal appeared late (c 800 A.D.) presumably under the influence of both Japan and China (Takamiya 1967: 14, 16).

China

The Late Neolithic in China includes food production but it is divided into millet growing in the north and rice growing in the south according to the ecological zones present. Permanent settlements, pottery, polished stone and domesticated animals are also present.

In North China the first appearance of bronze takes place in an incipient form of production with a bronze foundry at Yen-shih western Honan, in the first Erh-li-t'ou phase (c 1850-1650 B.C.) of the Shang dynasty (Chang 1968: 128, 199, 231-232, 437; Hsia Nai 1963a: 16, 1963b: 181; Fontein and Wu 1973: 28; Li Chu-tsing 1973: 419). Hsia Nai (1963a: 16; 1963b: 181) states that the earliest assemblages were found at Lo-ta-miao, Ching-chou and at Erh-li-t'ou, Yen-shih county, and at this early period the finds already include small objects of copper and bronze. However, Loehr (1968: 14), Chang (1968: 204) and Wheatley (1971: 71) say that Lo-ta-miao (one of 26 sites at Cheng-chou) is a pre-metallic site, therefore copper and bronze cannot be present at Lo-ta-miao and so must be present at Erh-li-t'ou. Soper (1966: 10-12), who has taken his information from the K'ao-ku 1965/5 report, does not mention the existence of copper-made objects at all. The Neolithic in the rest of China continued for different lengths of time (Barnard 1972: 26-27). The Lungshan, the last phase of the Neolithic period provided the prototypes, in implements of bone, stone and antler, for the bronze implements found at Erh-li-t'ou (Li Chi 1957: 53; Cheng Te-k'un 1960: 169-170). The Lungshan vessels of pottery and wood (Creel 1937: 105; Watson 1966: 44; Kidder 1956: 8; Li Chi 1970: 121; Kao Jen-tsun 1970: 97; Cheng Te-k'un 1973: 208;

Wheatley 1971: 71; Loehr 1968: 11) and the Lungshan designs on pottery, wood, bone and cloth (Li Chi 1970: 121; Shih Hsio-yen 1972: 274) provided models for the bronze assemblages later in time than Erh-li-t'ou, such as at Cheng-chou 50 miles east of Erh-li-t'ou. Chang (1968: 232) states that some Neolithic pottery types appear to be imitating metal types and that the occurrence of bronze vessels earlier in time cannot be ruled out.

Chang (1964: 371) believes that in southeast China bronze metallurgy emerged from connections with North China. Solheim (1973: 25-29) and Bayard (1975: 167-168) have suggested connections with Southwest China and Southeast Asia for bronze metallurgy in southeast China.

In Southwest China, northwest Yunnan, the first steps in metallurgy have been found at the village site of Chien-ch'uan, dated to 1150±90 B.C. (ZK-10) (Chang 1973: 526); both hammered and cast copper objects were excavated (Chang 1968: 427; Barnard 1972: 29). The earliest well documented bronze assemblage is from one tomb at the burial site of Ta-p'o-na about 60 miles southeast of Chien-ch'uan, and is dated to the middle period of the Eastern Chou dynasty c 600 B.C. (Chang 1968: 429; 1975: 170). The Chien-ch'uan site has been classified as essentially Chinese Lungshan Period Neolithic in character, based on the pottery and tools present (Chang 1968: 427; Barnard 1972: 28). Chang (1968: 427) states that the bronze culture of Ta-p'o-na is far advanced over that at the Chien-ch'uan copper site but it is a more primitive stage of metallurgy and possibly antecedent to the metallurgy found at nearby (about 130 miles southeast) Shih-chai-shan. This is not far from North Vietnam, the

area of the advanced Dongs'on bronzes. However Von Dewart (1969: 10) warns that Yunnan is a territory with a widely diversified surface relief, accounting for equally diverse climatic zones and ecological environments and we may have to infer a similar stratification of simultaneous, apart from successive, prehistoric cultures for the region as a whole. At Ta-p'o-na, the Chinese tradition of the Shang and the Chou is represented by the casting methods, the tomb construction, some of the bronze vessel types and the chopsticks but the forms of the axes and the other socio-technic items, and the decorative art characterizes an essentially indigenous civilization (Chang 1968: 429).

Taiwan's Late Neolithic and early metal stages came in by way of China's southeast coast (Solheim 1963: 258; Chang 1963: 249, 1964: 373); some reportedly influenced by North China (Chang 1964: 371, 1968: 160-161) and some by northern Indochina and the Dongs'on culture (Solheim 1963: 256, 258).

Vietnam

The Late Neolithic in Vietnam was characterized by two different economic types -- one, shell collecting cave dwellers, and two, agricultural open air dwellers -- who possessed polished stone and ceramics. Bronze appearance in North Vietnam dates from 1500 B.C. (Solheim 1974) and bronze working in South Vietnam dates to 3950 \pm 250 B.P. (Solheim 1970: 148). Boriskovsky (1966: 84-85) states that the much younger Dongs'on culture (c 300 B.C. Solheim 1967: 899) developed out of the Main Neolithic culture in Vietnam.

Cambodia

The oldest known Neolithic site in Cambodia is the Laang Spean deposit in northwest Cambodia dating from c 4290 B.C. to 830 A.D. and characterized by ceramics, flaked stone and a hunting and gathering economy. Other Neolithic sites with a shell gathering economy date from 3420 B.C. in South Cambodia and from 1280 B.C. in Central Cambodia (Mourer 1971: 35-36, 41). The site of Mlu Prei in northern Cambodia has similar bronze axes, fragments of molds and associated artifacts, such as pottery, that indicate some relationship with Non Nok Tha in northeast Thailand but the dating is not known (Solheim 1967: 900; Bayard 1971: 17-18).

Thailand

The Neolithic in Thailand was characterized by horticulture, domestication of animals with continued hunting, gathering, pottery, polished stone tools and a village social grouping; the Neolithic in Thailand is said to have been earlier and thus distinctive from the rest of East Asia (Solheim 1970: 146-147, 1972: 34-36, 38; Gorman 1971: 315; Bayard 1970: 135, 141). There was an early population shift from the mountain valleys to the lowland plains triggered by rice agriculture around 6500 B.C. (Gorman 1971: 316). The earliest metal object found in Thailand is the socketed copper tool from Non Nok Tha indirectly dated to the fourth millenium B.C. by supporting data such as pottery and metal work from other Southeast Asian locations (Solheim 1970: 145-149) and a C 14 date of 3590 \pm 320 B.C. (GAK-1034) (Bayard 1972: 1411). Early bronze

casting is evident also at Non Nok Tha dating from c 2300 B.C. (Bronson and Han 1972: 323; Solheim 1968: 62; Bayard 1972: 1412). There were indications of cultural continuity from the Neolithic to the Bronze Period in the stone adzes, shell and stone beads and pottery (Bayard 1970: 125, 135-141). Although some pottery similar in form to Chinese pottery (*ibid.*: 136) appeared in the same level as the first bronze objects (*ibid.*: 125), the earliest bronze technology used in North China, several hundred years later, with clay molds and different bronze constituents bears very little resemblance to that used at Non Nok Tha (Bayard 1970: 139; 1971: 13). The importance of this later evidence is that it shows possible routes of interaction and influence from Neolithic times. Similarly, there is no apparent relationship to the bronze cultures of the Indus Valley in India (Pakistan) at the end of the third millennium B.C. These utilized, among other techniques not known in Thailand, open single-valve molds to produce flat tanged axes, compared to the Non Nok Tha technology of bivalve sandstone molds to produce socketed axes (Bayard 1970: 139, 1971: 3, 7-8, 13, 15-16, 1972: 1412; Solheim 1972: 35, 41; Lamberg-Karlovsky 1967: 151-152).

In summary, the results of this investigation of the Neolithic period to the first appearance of metal production in East Asia show that the earliest appearance of metal assemblages occur in the Minusinsk Basin, East Siberia, in the Erh-li-t'ou site, North China, at Ta-p'o-na, Southwest China and at Non Nok Tha, Thailand.

The introduction of stock-breeding to the steppes of the Minusinsk Basin from the West by European^o racial types during the Neolithic was to a

receptive environment, composed of a culture with a hunting subsistence and a steppe with pasture land, thus a pre-adaptive factor existed in the Minusinsk area for the successful adoption of the domestication of animals. This then resulted in the first food production area in East Siberia and paved the way for the further adoption of the cultural products of the West, such as pottery forms, decorations and metal objects and technology from the Caucasus, the Aral Sea region, the Urals and the Kazakhstan steppes.

The earliest bronze assemblage in North China is from the Erh-li-t'ou site; the bronze implement forms found their prototypes in the implements made of bone, stone and antler of the last phase of the Neolithic period, the Lungshan. Slightly later bronze vessel forms and designs on bronze from Cheng-chou sites also had their prototypes in pottery and wood for the former, and in pottery, wood, bone and cloth for the latter, in the Neolithic period. Thus the antecedents of the bronze production in North China are the forms and designs of implements and vessels and the technology of pottery production found in the Late Neolithic period.

In Southwest China, the earliest copper assemblage at Chien-ch'uan appeared in an essentially Chinese Neolithic cultural context. The earliest bronze assemblage at Ta-p'o-na is apparently derived from the North Chinese tradition in casting methods, tomb construction and some of the vessel types while other aspects of the assemblage, such as axe forms, sociotechnic items and the decorative art represent an indigenous tradition.

The earliest appearance of metal objects in Southeast Asia is at Non Nok Tha. There were indications of cultural continuity from the Neolithic to the Bronze period in the forms and decoration of the pottery, in the stone adzes, and the shell and stone beads. The forms of the stone adzes are unrelated to the forms of the bronze axes (Bayard 1970: 135) and they are both unrelated to the copper tool (Bayard 1971: 5). The methods of casting and the forms of the bronzes at Non Nok Tha are unrelated to either the Indus civilization or to the Chinese cultures.

CHAPTER THREE

THE EARLIEST BRONZE ASSEMBLAGES

As mentioned earlier, the earliest metal work done by ancient people was the hammering of native copper. It has also been established that the earliest bronze assemblages in East Asia were discovered in southern Siberia where they were preceded by copper working, in North China where earlier evidence of copper working has not been documented as yet and in southwest China and northeast Thailand where bronze working is documented as preceded by copper working.

North East Asia: Siberia

In the steppe area of the Minusinsk region, the Afanasiev culture at the end of the third millennium or beginning of the second millennium B.C. produced a few primitive copper objects -- crude platings of wooden vessels, the simplest leaf-like knives, hanging rings and needle cases (Okladnikov 1959: 22; Gryaznov 1969: 50). According to Jettmar (1950: 92) the end of the Afanasiev culture in the Minusinsk Basin is usually dated to 1700 B.C. Okladnikov (1959: 23) states that the succeeding culture is the Andronovo (earliest chronological stage of it being the Okunev), c 1500 - 1200 B.C., which produced metal celts, flap-eared axes, daggers and spearheads with collars. Gryaznov (1969: 39, 51) believes that the Afanasyevskaya (Afanasiev) stage at the end of the third millennium B.C. gave way at the beginning of the second millennium B.C. to the distinctive

Okunev culture and that there was no link between the Afanasiev and the Okunev nor was the Okunev culture an early phase of the Andronovo culture, since the Okunev skeletons were of the Mongoloid racial type. He also states (*ibid.*: 50, 51) that the metal objects of both the Afanasiev and Okunev cultures were copper -- needles, awls, knife blade, and a fish-hook, adding copper ornaments and copper repairs of wooden vessels for the Afanasiev period. He (*ibid.*: 90) adds needles and awls to the bronze inventory of implements and beads, pendants, ear-rings or plaques (hanging rings?) to the bronze inventory of ornaments in the Andronovo period. Gryaznov (1969: 90) also noted that copper needles were present in Andronovo times at Minusinsk. Chard (1974: 145, 148-194) notes that the culture succeeding the Afanasiev was the Okunevo (Okunev) with rudimentary bronze work, which he does not elaborate on, followed by the sedentary, agricultural Andronovo culture c 1500-1200 B.C. Sulimirski (1970: 261) remarks that the Andronovo culture began in the eighteenth or seventeenth centuries B.C. with the earliest period of its development lasting up to around 1500 B.C. Chard's date for the Andronovo culture is the most recently published one, and, although I suspect it merely echoes Okladnikov's estimated date of c 1500-1200 B.C., that is the one that will be used in this discussion. Another problem that needs clarifying is Okladnikov's listing of celts and flap-eared axes as separate items while Sulimirski (1970: 286) and Gryaznov (1969: 239) report celts and axes as representing the same objects, thus axes (celts). These artifacts will be treated here as the indeterminate category of weapons/implements and listed in the tables as weapons and implements. The daggers reported from Minusinsk will be

equated with the reported knives of the other assemblages and will also be treated as the indeterminate category of weapons/implements.

No precise data are available on the analyses of bronze except for the "Minusinsk Bronze Age", which may or may not refer to the earliest assemblages in the area, which states that the tin content of bronze was not more than 6% (Voce 1951: 106, 109). Gryaznov (1969: 90) notes that Andronovo Minusinsk bronze was a "real bronze", an alloy of copper and tin.

Tin, copper and other ores were abundant in the Altai and Trans-Baikal Mountains (Okladnikov 1959: 23; Chard 1974: 163) and smelting was carried out at the mines. Mongait (1959: 146) reports that during Andronovo times tin mines were in the upper reaches of the Yenisei and copper mines were located on the Minusinsk steppes.

There is no mention of casting procedures specifically for the earliest assemblages but the "Minusinsk Bronze Age" is stated as using sand, clay or stone split moulds with clay cores (Voce 1951: 106-109).

Central and South-East Asia: China

North China

Erh-li-t'ou, with a large settlement and a highly stratified burial pattern, in Yen-shih county of northwestern Honan, c 1850-1650 B.C., is apparently culturally ancestral to the later bronze phases of the Shang dynasty known from Cheng-chou and Anyang (Chang 1968: 196; Cheng Te-k'un 1975: 26; Soper 1966: 23). The small bronzes found include arrowheads,

fishhooks, knives which are a crudely angular version of the semi-lunar knife, awls and bells (Chang 1968: 199; Loehr 1968: 14; Fontein and Wu 1973: 28; Soper 1966: 12). Chang (1968: 199) adds spearheads, ornaments or art objects but no other source mentions ornaments or art objects so perhaps this is in reference to the bells, and Soper (1966: 23) states unequivocally that no bronze spearheads were present. Unfortunately the information in the original report is not available to a non-Chinese language reader but the illustration in Fang Yu-sheng's report (1965: 215-224, Plate 5) does not show spearheads. The presence of a bronze foundry is indicated by fragments of clay crucibles, bronze slugs and clay molds (Chang 1968: 199; Li Chu-ting 1973: 419; Soper 1966: 12).

No standardized composition existed in Shang times for bronze alloys, according to Cheng Te-k'un (1960: 158) and Kidder (1956: 18) although Kidder (*ibid.*) and Li Chung (1975: 259-263) state that early Chou dynasty sources (K'ao Kung Chi) give the already government prescribed ratio of tin to copper, depending on the surface required and on the purpose of the object. Different sources give varying ratios for tin in ancient bronze --5-6% to 30% (Cushing 1967: 64), 7-20% (Gettens 1967: 212), 10-20% (Kidder 1956: 18; Watson 1971: 79) with the percentages as high as 50% for mirrors. Barnard (1961: 191, 193, 197) reveals that according to tests the six K'ao Kung Chi formulae were merely unreliable conjectures and that by Late Shang times the tin content still varied from 1.83% to 20.32% and the copper content varied from 76.7% to 95.2% in 8 samples; additional information from tests showed that zinc is absent and lead

amounts to less than 3% in Shang bronzes with the tin content being lower in weapons and utensils.

Ores, both copper and tin, were present in many areas around the Yen-shih area (Barnard 1961: 50; Shih Chang-ju 1955: 105). Nothing is known of ore processing at this time but it is presumed that smelting was carried out beside the mines (Barnard 1961: 179).

The method of casting bronze in Early Shang times was by direct casting in molds with the simplest solid casting of weapons, tools and ornaments being done in two-piece molds. Often the molds in such cases were carved from blocks of stone (Barnard 1961: 243). Barnard (1961: 243) states that there is no evidence yet for the use of open single molds but Cheng Te-k'un (1960: 163, 1975: 26) states that the simpler artifacts at Yen-shih were cast in open or valve molds and Chang (1968: 247) agrees that single molds were used in Shang times. The use of a clay core permitting the casting of hollow objects such as bells was the next stage in metallurgical development (Barnard 1961: 250) and is already seen in the Erh-li-t'ou remains. Cire-perdue, the earlier casting method of the West, was thought to have been introduced and practiced in Shang and Chou China (Penniman 1951: 120; Kidder 1956: 19; Savage 1968: 20; Watson 1971: 77) but no bronze cast by the cire-perdue process has been unearthed from any pre-Han sites yet (Barnard 1961: 86, 105). The first real evidence of cire-perdue methods of casting uncovered in a pre-Han site, in Late Chou China (c 200 B.C.) was in northwest Yunnan, southwest China, where the technique was introduced possibly from India or the Ordos (Barnard 1961: 158, 1967: 186).

Southwest China

In northwest Yunnan, north of Lake Erh at Chien-ch'uan, Hai-men-k'ou, a habitation site yielded 14 copper artifacts including hammered curved knives, awls, chisels, rings, fishhooks, bracelets and cast celts or axes, plus part of a clay mold. This site, although classified as essentially Chinese Lungshan period Neolithic in character, shows the earliest phase of metallurgy in the area. Barnard (1972: 24-25, 28-30) converts the C 14 date of 1150 ± 90 B.C. (Z-10) into an earlier Bristlecone Pine date of 1353 ± 154 B.C. believing that this gives a more accurate date for Chien-ch'uan.

The earliest bronze assemblage in Yunnan, from a burial at Ta-p'o-na, Hsiang-yun, just southeast of Lake Erh, includes a decorated house-shaped coffin assembled from seven pieces, containing a bronze stick. One hundred bronze artifacts were recovered from the burial fill. The bronzes were implements -- hoes, plow blades, axes, dibbles, knives; weapons -- spearheads and ends, swords, picks, fan-shaped axes; vessels -- tsun goblets, cups, tou fruitstands, a cooking pot; spoons, chopsticks, kettledrums, 2 gourd-shaped musical sheng, a bell, models of houses, cattle, horses, sheep, pigs, dogs, chickens, ornaments and "other miscellaneous tiems" (Chang 1968: 428).

Chang (1968: 429) notes that the composition of eleven selected bronzes from Ta-p'o-na appears to be uneven and uncontrolled, with copper ranging from 79.60% to 97.63% and the tin ranging from 0.19% to 16.34%; lead in 6 objects varied from 0.52% to 3.46% and one other object had a trace only.

No scientific dating for the site is available but Chang (1968: 429) places it in Middle Eastern Chou times, and gives the estimated date as 600 B.C. (Chang 1975: 170).

Sources of ores of copper and tin are plentiful in Yunnan (Heekeren 1967: 117; Barnard 1961: 50; Shih Chang-ju 1955: 105).

No molds, crucibles or other evidence of bronze production were documented as being excavated.

South East Asia: Thailand

In northeast Thailand, in the site of Non Nok Tha a copper socketed tool, recovered from a burial with extensive grave furnishings, and two small pieces of bronze were found at a lower level (Early Period III) and dated indirectly to 3590 \pm 320 B.C. (GAK-1034) (Bayard 1972: 1411). A different date was obtained by using the thermoluminescence method, giving an estimated date of 2700 to 2500 B.C. (Bayard 1972: 1411-1412). The next levels, habitation and burial (Middle Period III), produced 28 bronze bracelets, 4 socketed bronze axes, numerous bronze lumps from casting spillage, 6 pairs of double-valve sandstone molds and six clay crucibles; the axes are suggested as having functional distinctions (Bayard 1971: 5; Solheim 1968: 59-62, 1970: 147). The dating of Non Nok Tha has been queried by Loofs (1974: 59-60) as being based on controversial dates from other areas and on preliminary evidence of thermoluminescence dates given by Bronson and Han (1972: 323). Pittioni (1970: 158), in his report on the analysis of eight bracelets and one socketed axe from Non Nok Tha, has made a puzzling statement in regard to their age -- he gives the tradi-

tional date of the eighth century B.C. for bronze working in Southeast Asia but he does not say how he arrived at this conclusion for these Non Nok Tha bronzes other than by referring to Solheim's 1967 and 1968 articles; Solheim (1967: 899, 1968: 62) gives a date "about 2500 B.C." for these objects. Bayard (1975:168) states that there are now "37 dates from the site and the tendency to support a pre-2000 B.C. date for bronze is quite clear, although not conclusive." A chart of Non Nok Tha dates, as of 1975 is in the Appendix.

No evidence has been excavated to show the presence of warfare, urbanization, or any social or political organization although there were differences in wealth and prestige shown in the burials (Solheim 1970: 147, 157-158).

The fact that no trace of copper, tin or lead ores has been found in association with the bronze casting equipment leads to the assumption that the ores were smelted at their source or the refined metals or alloyed bronze came in by way of trade (Solheim 1972: 41). The sources of the ores are rather distant from the site; copper deposits in vein and free copper were found 80-100 km. away (Pittioni 1970: 160), copper ore appeared 135 km northwest with lead ore not far away from this copper deposit and tin ore was noted 250 km. northwest (Solheim 1969: 135, 1970: 152).

Analysis of two samples from the socketed copper tool showed impurities of aluminum, iron, phosphorus, arsenic and mercury. The traces of phosphorus, arsenic and iron suggest that the copper had been treated in some way, either by roasting or smelting, before enough "pure"

copper was available for cold hammering (Solheim 1970: 152, 1972: 41; Bayard 1972: 1411). One of the small pieces of bronze from this same early level (Early Period III) was analyzed by using the electron probe, and spot analysis revealed 94-96% copper and 4-6% tin with no arsenic, phosphorus, iron or lead present -- indicating a deliberately made tin bronze (Bayard 1972: 1411). Spectrographic analysis of 12 samples from five of the bronze objects from the next level (Middle Period III) displayed that equal proportions of tin and lead had been deliberately added in most cases to copper containing arsenic (Pittioni 1970: 158-159; Solheim 1970: 152; Bayard 1971: 7).

The casting of the socketed bronze axes was with sandstone double molds and core, and the bracelets were cast either in double molds or by the *cire-perdue* process (Bayard 1971: 3).

CHAPTER FOUR

CONCLUSIONS

The conclusions from the earliest bronze assemblages will be based on tabulations of the presented information.

TABLE II. PRESENCE OR ABSENCE OF ARTIFACT TYPES
IN THE EARLIEST ASSEMBLAGES

<u>Artifact</u>	<u>Siberia</u>	<u>China</u>			<u>Thailand</u>
	<u>Minusinsk</u>	<u>Erh-li-t'ou</u>	<u>Ta-p'o-na</u>	<u>Chien-ch'uan</u>	<u>Non Nok Tha</u>
<u>Copper</u>					
knives	+			+	
axes				+	
awls	+			+	
chisels				+	
fishhooks	+			+	
socketed tool					+
needles	+				
rings	+			+	
needle case	+				
bracelets				+	
plated wooden vessel	+				
axe mold				+	
<u>Bronze</u>					
knives	+	+	+		
axes	+		+		+
spearheads	+		+		
spearends			+		
swords			+		
pick			+		
arrowheads		+			
fishhook		+			
needles	+				
stock			+		
axes	+		+		+

Continued

TABLE II (Continued)

Artifact	Siberia	China			Thailand
	Minusinsk	Erh-li-t'ou	Ta-p'o-na	Chien-ch'uan	Non Nok Tha
<u>Bronze (continued)</u>					
hoes			+		
plow blades			+		
awls	+	+			
dibbles			+		
cups			+		
fruitstand			+		
cooking pot			+		
spoons			+		
chopsticks			+		
goblets			+		
bells		+	+		
gourd <u>sheng</u>			+		
kettledrum			+		
art objects			+		
ornaments	+	+	+		+
coffin			+		
mold		+			+
bronze slugs		+			+
crucibles		+			+
miscellaneous			+		+

In summary of Table II, the first obvious fact is that the burial at Ta-p'o-na is represented by many more types of bronze artifacts than the other assemblages. The second fact is that the bronze assemblages of Ta-p'o-na together with the copper assemblage of Chien-ch'uan, both in northwest Yunnan, yielded the majority of metal artifact types.

The assemblages with the most types of copper items are Minusinsk and Chien'ch'uan with 7 types each, followed by Non Nok Tha with one type and Ta-p'o-na and Erh-li-t'ou with none.

The number of different bronze artifact types in the assemblages is represented in descending order by Ta-p'o-na with 23 types, Minusinsk with 7, Erh-li-t'ou with 6, Non Nok Tha with 3 types and Chien-ch'uan with none.

However there are other considerations that are more important for understanding the beginning of bronze technology than the bronze artifact type frequencies in an assemblage. One of these is the chronological age of the assemblage. It is evident that the majority of the dates given for the earliest assemblages have been arrived at relatively and speculatively. There is one C 14 date for the copper site of Chien-ch'uan and an inconclusive date for Non Nok Tha. However if this is all we have to work with at the moment, this is what we have to use.

To simplify the points in this summary, smaller tables will be used. All dates given are B.C.

TABLE III. DATES OF EARLIEST ASSEMBLAGES
(Minusinsk, Non Nok Tha, Chien-ch'uan, Erh-li-t'ou, Ta-p'o-na)

Copper		Bronze	
Minusinsk	early second millenium	Non Nok Tha	pre 2000
Non Nok Tha	c 2700-2500	Erh-li-t'ou	c 1850-1650
Chien-ch'uan	1150 \pm 90	Minusinsk	c 1500-1200
Erh-li-t'ou	no copper	Ta-p'o-na	c 600
Ta-p'o-na	no copper	Chien-ch'uan	no bronze

TABLE IV. NUMBER OF CATEGORIES OF ARTIFACT TYPES
IN FIVE EARLIEST ASSEMBLAGES

Copper		Bronze	
Minusinsk	4	Ta-p'o-na	7
Chien-ch'uan	3	Erh-li-t'ou	4
Non Nok Tha	1	Minusinsk	3
Erh-li-t'ou	0	Non Nok Tha	3
Ta-p'o-na	0	Chien-ch'uan	0

TABLE V. CATEGORIES OF COPPER ARTIFACT TYPES
IN THREE EARLIEST ASSEMBLAGES

Minusinsk	early second millenium	weapons/implements implements domestic utensil ornaments
Non Nok Tha	c 2700-2500	weapon/implement
Chien-ch'uan	1150 \pm 90	weapons/implements implements ornaments

No conclusions can be made on categories of copper artifact types based on chronological position. Actually no viable comparison can be made among the three copper assemblages. As has been noted previously the earliest metal work done by man was by hammering native copper. Successive steps in the development of metallurgy were proposed also but there is no assurance that these developmental stages will be represented in every area. Chien-ch'uan progressed no further than hammered and cast copper for unknown reasons. Minusinsk showed a development from a hammered copper stage to a bronze stage probably as the result of the entry of these elements from the West, as shown earlier. The excavated area of Non Nok Tha is relatively small and with one example of copper only, no conclusions can be drawn on it for the beginning of bronze technology in the area.

Already it has been noted that comparison among the earliest centres of bronze production is hampered by inadequacies in sampling and dating. In addition, we are dealing with societies at different levels

TABLE VI. CATEGORIES OF BRONZE ARTIFACT TYPES
IN FOUR EARLIEST ASSEMBLAGES

Non Nok Tha	pre 2000	weapons/implements implements ornaments
Erh-li-t'ou	c 1850-1650	weapons implements ornaments musical instruments
Minusinsk	c 1500-1200	weapons implements ornaments
Ta-p'o-na	c 600	weapons implements ornaments musical instruments domestic utensils art objects ideological symbol

of development, in which bronze production plays differing roles. Earlier the way in which bronze metallurgy can occur in very different social contexts was also mentioned. We may now explore briefly the social context of bronze production at the earliest locales.

According to Steward (1955: 52-55) the levels of sociocultural integration range from nuclear family through folk society to state or ganizational systems; they are qualitatively different systems which represent successive developmental stages. Productive processes may become patterned around collective hunting, fishing, herding or farming and society acquires a structure appropriate to the particular kinds of interfamilial relations that develop in the cultural tradition. This lower level of integration then is based on multikin structure. A still

larger system of integration, a folk society, appears when these earlier multikin groups become functionally dependent on each other for food production, trade goods and offensive and defensive warfare; this dependency could result in political hierarchy and class and status differentiation. At the state level new institutions appear for controlling those aspects of life that are of concern to the state, such as government structure and social stratification.

Binford (1972: 93-101) explains the three relevant artifact types based on their primary functional context in the society: one, technomic--- artifacts used directly in coping with the physical environment; variability is explained by the existing ecology; two, socio-technic -- artifacts used in the social subsystems as "the means of articulating individuals into cohesive groups capable of maintaining themselves and manipulating the technology" and changes in this type of artifact can be related to changes in the structure of the social system; three, idio-technic -- artifacts used in the ideological part of the social system. Formal stylistic characteristics for reinforcing belief, custom and values cross-cut all these general classes of artifacts.

Binford (ibid.: 95) theorizes that if durable metal (copper) artifacts which require as much effort to produce as less durable stone and bone artifacts, are made for nonutilitarian use then they are primarily socio-technic items. He (ibid.: 99) further proposes that there is a direct relationship between these status symbols and the level of sociocultural integration of the culture; small group size at a low level

of integration will have a low number of status symbols and larger groups at a larger level of social integration with more than an egalitarian system of status grading will have a higher number of status symbols or socio-technic items. Binford (ibid.: 100) in reference to the Old Copper Culture of North America, states that the frequent occurrence in burials of copper artifacts of technomic form, with apparent lack of technomic efficiency and relative scarcity, suggest their primary function was as socio-technic or status items. It appears that this conclusion of Binford's can also be applied to other cultures, such as those of East Asia, and other metals, such as bronze.

Following the expositions of Steward and Binford we may expect to find in the earlier lower levels of integration, such as family or multikin groups, that the majority of categories of artifact types will be technomic, relating to food production and will be of bone or stone with no evidence of "exotic" metal status symbols being produced in the culture. The next larger level of sociocultural integration, the folk society, with some evidence of political control and role differentiation apparent, would include categories of artifact types relating to food production and warfare with a minimum of socio-technic or metal status symbols. As the level of sociocultural integration becomes larger and later in time, at the state level, we may expect to find evidence of social stratification, ideological beliefs and a higher number of socio-technic items, of metal and other materials. Expectations, based on the two larger levels of sociocultural integration, folk societies and state societies, and on the development stages between, can be used to explore

the relationships of the categories of bronze artifact types to the social integration at Non Nok Tha, Erh-li-t'ou, Minusinsk and Ta-p'o-na in order to ascertain their relative levels of social organization for the establishment of the beginning of their bronze technology.

Table VI shows that the earliest of the assemblages, Non Nok Tha, with postulated rice agriculture and domesticated animals, a low level of political organization and social stratification (Bayard 1970: 141), which is possibly role differentiation rather than stratification (thus a folk society), has produced the expected results -- the lowest level of socio-cultural integration with the fewest categories of artifacts, weapons/ implements, implements and socio-technic items, ornaments.

Erh-li-t'ou, with millet agriculture, animal domestication, large settlement pattern and slave burials (Chang 1968: 196-198; Soper 1966: 11) indicates a stratified society with political organization, therefore at the developing state level of sociocultural integration. This second oldest site also produced the expected results -- a higher level of social integration with the second highest number of categories of artifact types, weapons, implement, and socio-technic categories of ornaments and musical instruments.

Minusinsk with the third oldest chronology did not fulfill the expectations. Agriculture and animal domestication were present but there is small evidence for social differentiation or political organization since the only categories were weapons, implements and socio-technic ornaments. A lower level of sociocultural integration, folk society, is

shown, possibly due to the metallurgy being introduced to a culture with limited agriculture.

Ta-p'o-na, the youngest site represented, also fulfilled the expectations by showing the most categories of artifact types with the most variation within the categories. Here were advanced agriculture and animal domestication and together with the categories of weapons, implements and socio-technic items of ornaments, musical instruments, domestic utensils, and art objects and the ~~ideo~~-technic item of a complex decorated coffin, show a higher degree of social stratification and political organization and give evidence of ideological beliefs. Thus Ta-p'o-na represents the most advanced stage of sociocultural integration at the incipient state level with the most complex technology of the four earliest bronze assemblages.

To summarize the evidence then, it would seem that Non Nok Tha and Minusinsk were at the folk society level of sociocultural integration and possessed the fewest categories of artifact types -- technomic and one category of socio-technic items. However, Minusinsk has three types of artifacts in each of the two technomic categories of weapons and implements and Non Nok Tha only has one type in each and they each only have one type of artifact in the socio-technic category. Therefore, Minusinsk is at a larger or higher level of folk society integration than Non Nok Tha.

Erh-li-t'ou is at a higher level of integration again, showing a developing state level with two types of artifacts in the weapons and

implements technomic categories and one type of artifact in each of the two socio-technic categories.

The Ta-p'o-na bronze assemblage, although representing only one excavated burial, shows a more advanced level of sociocultural integration existed at Ta-p'o-na than at Erh-li-t'ou, and the artifacts also represent the most complex technology of the four earliest assemblages. There are six types of artifacts in the technomic category of weapons and five types in the technomic category of implements and the four socio-technic categories contain eleven types of artifacts. The Ta-p'o-na assemblage also possesses one type of artifact in the idio-technic category.

There may still be earlier sites than all of these in the same areas; sites that have only flat cast objects that were produced before the use of a core with a double mold was known. Minusinsk may yet be shown to be of an earlier date than that accepted at this time and the lower level of sociocultural integration accompanied by the fewer categories of artifact types would then "fit" the expectations. Or, with a change in the expectations of archaeologists in the region, we may begin to learn a great deal more about sites other than burials.

TABLE VII. EVIDENCE OF CASTING FROM THE
FOUR EARLIEST BRONZE ASSEMBLAGES

<u>Assemblages</u>	<u>Molds</u>	<u>Bronze Slugs</u>	<u>Crucibles</u>
Non Nok Tha	+	+	+
Erh-li-t'ou	+	+	+
Minusinsk			
Ta-p'o-na			

Evidence of casting is found only in the two earliest sites, or is reported from only these sites, Non Nok Tha pre 2000 B.C. and Erh-li-t'ou c 1850-1650 B.C.

Sand, clay or stone split-molds with clay cores have been reported from the "Minusinsk Bronze Age" but again with no specific mention of the earliest Andronovo period of the Minusinsk bronzes. The possibility of the "other miscellaneous items" found at Ta-p'o-na including evidence of bronze working cannot be ruled out by a non-Chinese language reader. However, as the tomb appeared to belong to a person rather high up in the hierarchy of a stratified society, the possibility of the presence of cores or molds as evidence for production methods is not likely. Molds used at Erh-li-t'ou were clay, single or double for the weapons and tools with utilization of two piece valve molds and clay cores for the bells but there is no further description or analysis of the bronze slugs and clay crucibles other than mention of their presence. Cheng Te-k'un (1960: 162) describes Early Shang crucibles as being made with straw tempered clay.

At Non Nok Tha the molds are double-valve sandstone types and the crucibles are of clay, heavily tempered with rice chaff and straw (Bayard 1971: 7). The axes were made using the double-molds and cores and the bracelets using either double molds or the cire-perdue process. No explanation has been given for the suggestion that cire-perdue was used -- one receives the impression that the only reason this was mentioned was because earlier thinking has assumed influences to the area came from the West where cire-perdue was the preferred method of casting.

It is interesting that on the evidence of "fragments of clay crucibles, bronze slugs and clay molds" found at Erh-li-t'ou, Chang (1968: 199) states that this indicates a foundry at the site, while the similar evidence of whole crucibles of clay, sandstone molds and bronze fragments discovered at Non Nok Tha only produces the statement that bronze working went on there (Solheim 1968: 62). It is obvious that more than this reported "evidence" was used to come to these conclusions. As has been demonstrated, Erh-li-t'ou was at the sociocultural level of developing state integration with a large settlement and thus was advanced beyond the folk society integration of Non Nok Tha where the kinship/descent groups were organized for metal working (Rowlands 1971: 217).

TABLE VIII. CHEMICAL ANALYSIS OF EARLY BRONZE ASSEMBLAGES

Assemblage	Cu	Sn	Pb	Details
Non Nok Tha	94-96% + + +	4-6% + +	+ +	one early fragment later objects, 12 samples of 5 objects, equal proportions of Sn, Pb
North China (Anyang)	(76.7-95.2%	1.83-20.32%	3%	8 samples Late Shang)
Minusinsk	(94%	6%		2 samples "Minusinsk Bronze Age")
Ta-p'ö-na	79.60-97.63%	0.19-16.34%	0.52-3.40%	11 selected bronzes; this percentage of lead in 6 samples, trace in 1 other

It is very difficult to come to any conclusions on the comparisons of the content of bronze from the assemblages.

The one early small fragment from Early Period III, Non Nok Tha, is apparently pure tin-bronze as are the two samples from the "Minusinsk Bronze Age" -- again these may or may not be from the earliest assemblages in the area. However, it is worth noting that the two assemblages that appeared to be of similar low levels of sociocultural integration, folk societies, and similar in the casting method, may again be similar in bronze analysis. The later Non Nok Tha bronze objects from Middle Period III are analyzed by presence and absence only, therefore comparisons of the percentages of the constituent elements are not possible in this case.

The analysis listed for North China is not on material from Erh-li-t'ou but is on samples from Late Shang Anyang, and as such can give only a possible general idea of the bronze content for Early Shang time. This, then, precludes using this information for comparison with other earliest assemblages. However, it has been stated (Barnard 1961: 190-192) that copper content decreased chronologically from Late Shang times (c 1401-1122 B.C.) through Western Chou and Eastern Chou times and that the tin content varied widely in Shang times and that Late Chou samples (18) contained more tin than Early Chou samples (18). All Anyang samples (8) contained less than 3% lead with a slightly higher percentage in both Chou periods. Barnard (ibid.: 192) warns that the full significance of these conclusions cannot be assessed without information on individual sites and proper grouping of like artifacts.

The Ta-p'o-na analysis, which differs from the percentages of constituent elements given for Non Nok Tha and Minusinsk, also should not be used for comparisons with early sites as it has been shown as the earliest assemblage in its area but not at an early stage of metallurgy. The chemical analysis of eleven selected bronzes (Chang 1968: 429) from Ta-p'o-na with an estimated date of 600 B.C. in Late Eastern Chou times does not appear to conform to the relative percentages of constituents from Shang to Late Chou times given by Barnard and just presented above; the copper content of the Ta-p'o-na selected bronzes does not decrease but increases instead; the variation in the tin and lead content is difficult to assess.

It is interesting to note similarities between the Late Shang Anyang analysis and the Ta-p'o-na analysis; the percentages of the constituents of the bronze are not completely dissimilar. What is of particular interest is that the tin range starts at 1.3% and 0.19% respectively and thus comes under what Coghlan (1951: 21-23) terms "accidental" bronze, produced prior to general knowledge of bronze, by using the enriched ores from a lode in which tin was associated with the copper; "true" bronze has been defined as containing in excess of 3% tin. The objects of Late Shang which produced these analytical results are not noted by Barnard (1961: 190-191) but the Ta-p'o-na burial objects, noted by Chang (1968: 429), with less than 3% tin content are shown in Table IX and the objects with more than 3% tin are shown in Table X.

TABLE IX. FOUR ARTIFACTS FROM TA-P'O-NA
WITH LESS THAN 3% TIN

<u>Artifact</u>	<u>Cu</u>	<u>Sn</u>	<u>Pb</u>
hoe	92.77%	0.19%	
spearhead	93.79%	2.35%	0.62%
gourd <u>sheng</u>	97.63%	1.32%	0.52%
horse figurine	93.80%	1.92%	1.12%

TABLE X. SIX ARTIFACTS FROM TA-P'O-NA
WITH MORE THAN 3% TIN

<u>Artifact</u>	<u>Cu</u>	<u>Sn</u>	<u>Pb</u>
adze	94.20%	3.71%	
spoon	84.13%	13.69%	
bell	79.96%	16.34%	trace
kettledrum	87.96%	6.87%	3.46%
ring	79.60%	14.75%	2.89%
coffin	89.60%	5.02%	2.25%

These two tables show that both utilitarian, technomic items -- hoe, spearhead, adze-- and socio-technic items -- sheng, figurine, spoon, bell, kettledrum, ring -- contain less than 3% tin and more than 3%; the idio-technic item, the coffin, contains more than 3% tin. Is there an explanation why some artifacts in the burial contain more tin and why some contain less tin? As shown, it cannot be explained on the primary functional context of the artifacts in the categories of technomic and socio-technic functions. The id^e/~~io~~-technic artifact, being a single example, may or may not be definitive. There appears to be several hypotheses that may explain this.

As noted earlier by Barnard (1961: 197) the tin content in bronze during Shang, Western Chou and Eastern Chou times is lower in the weapons and utensils than in ritual vessels. The analysis of the vessels at Ta-p'o-na has not been given but if we use the analysis for the other socio-technic items as ritual burial items, we find that Barnard's statement does not hold true in the case of the spearhead, and the adze, both containing more tin than the sheng and the figurine, but it does hold true in the case of the hoe which contains less tin than any other artifact. It also holds true in the case of the coffin, an ~~id~~^eo-technic item and as such may be termed a ritual item. Before Barnard's statement can be effective for answering the question of the varying amounts of tin found in bronze burial items, the term "ritual" must be more clearly defined.

Thus we arrive at other hypotheses; that the bronze craftsmen were not aware of the functional properties of more tin in bronze or if they were aware of them, they did not utilize them by producing harder, more durable utilitarian items than socio-technic items. It may also be a possibility that the low percentage of tin was an effort by some craftsmen to conserve the scarcer tin or simply resulted from using the "enriched" copper ores as a matter of course to produce "bronze" artifacts, in which case they are not what may be termed "accidental". It may also be a possibility that different smiths produced different specific items and had their own favourite formula for making bronze. Craftsmen may have deliberately used more tin to enhance the appearance and/or value of the objects.

Conclusions on chemical analyses of metal are that the individual artifact must be analyzed and compilations of categories of artifacts must then be compared as to their function within an assemblage and between assemblages. It is also obvious that much, much more work must be done in the area of analysis before any workable hypotheses can be forthcoming.

TABLE XI. APPEARANCE OF SIMILAR ARTIFACTS
IN THE FOUR EARLIEST ASSEMBLAGES

<u>Artifact</u>	<u>Minusinsk</u>	<u>Erh-li-t'ou</u>	<u>Ta-p'o-na</u>	<u>Non Nok Tha</u>
axes	+		+	+
knives	+	+	+	
spearheads	+		+	
bells		+	+	

This table demonstrates the limited appearance of similar types of artifacts in more than one assemblage. Axes were present in Minusinsk, Ta-p'o-na and Non Nok Tha. Knives appeared in Minusinsk, Erh-li-t'ou and Ta-p'o-na. Spearheads were found in Minusinsk and Ta-p'o-na and bells were excavated only at Erh-li-t'ou and Ta-p'o-na. The appearance of categories of artifact types in assemblages has already been discussed.

A comparison of the forms of the artifacts exhibit few visible similarities (Figures 1, 2, 3, 4 -- any scale given in the original publication for artifacts is included). The round ended axe appears at Ta-p'o-na (Figure 3:1) and at Non Nok Tha (Figure 4:1, 6) but the similarity ends at the top cutting edge; the design of the lower portion of the heads

is entirely different. The axes (celts) of Minusinsk (Figure 1:3) bear no relation in appearance to any other axe in the assemblages.

The leaf-shaped knives or daggers from Minusinsk (Figure 1:1, 2) are completely different in form from the crudely angular knife of the Erh-li-t'ou assemblage (Figure 2:1) and from the true daggers of Ta-p'o-na (Figure 3:3).

As no illustrations are available for Minusinsk spearheads, no visual comparison is possible.

The bell of Erh-li-t'ou (Figure 2:2) is simple and undecorated with one flange on the side and slightly flaring towards the base. The Ta-p'o-na bell (Figure 3:4) has straight sides, no flange and is decorated all over. Thus the only similarity is that they are both bells and both from assemblages in China.

The conclusion of the stylistic comparison based on the appearance of similar artifacts in the four earliest assemblages is that they appear to be different and probably are unrelated.

Final Comparison

This study has examined sites of early bronze technology in East Asia. The results of this examination have shown that the four earliest bronze assemblages occur over a wide geographical area (Figure 6: Map), southern Siberia to northeast Thailand, and cover a relatively broad time span, pre 2000 B.C. to c 600 B.C.

The southern Siberian assemblage of Minusinsk cannot be accepted for the beginning of bronze metallurgy in East Asia as the technology was

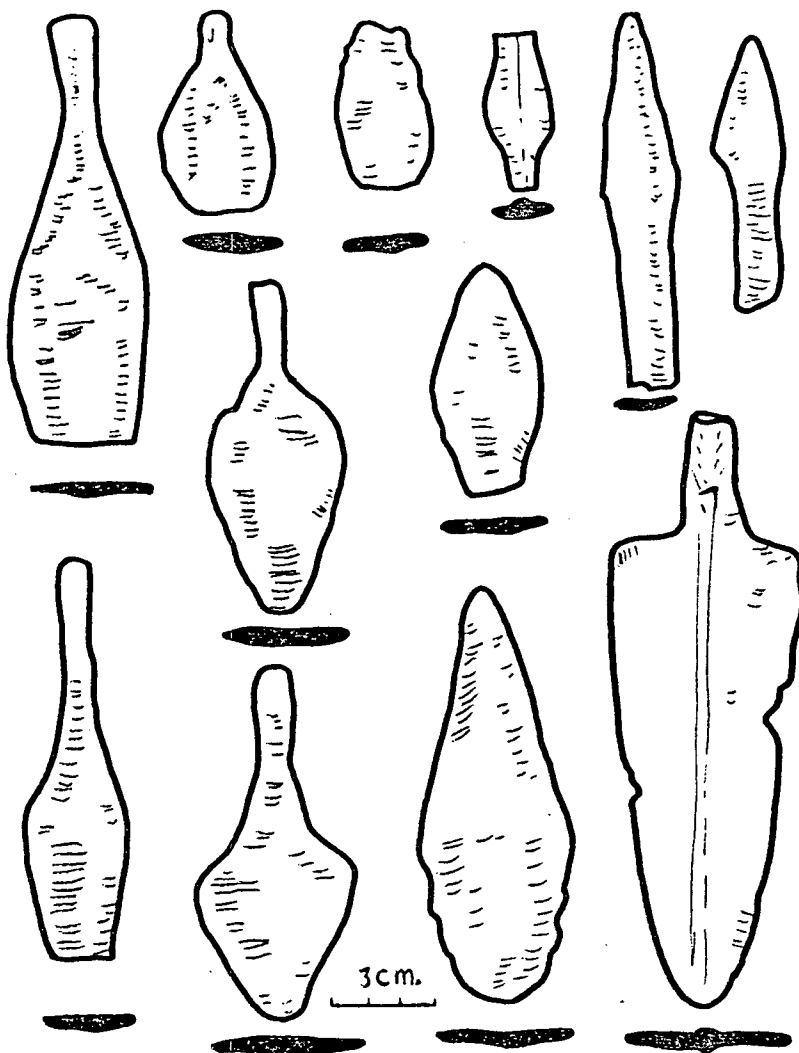
reportedly introduced from the West and there is some evidence for this but no evidence to the contrary; there is no evidence of ties with China or South Asia at early dates although there were some apparent similarities between Minusinsk and Non Nok Tha, in casting methods and in bronze composition.

The conclusion based on the complexity of technology is that the c 600 B.C. assemblage at Ta-p'o-na, southwest China cannot be included as showing the beginning of bronze production.

Two assemblages are left for comparison, Erh-li-t'ou, North China and Non Nok Tha, northeast Thailand. Erh-li-t'ou displayed an early state development level of sociocultural integration, based on evidence of social stratification, political organization and categories of artifact types. Non Nok Tha evidenced a folk society level of sociocultural integration with copper preceding bronze, and only one category of socio-technic items. The casting procedures for both assemblages are different in that either single or double clay molds were used at Erh-li-t'ou and double sandstone molds were utilized at Non Nok Tha; clay cores were used in both assemblages; cire perdue has been mentioned as a possibility at Non Nok Tha (Middle Period III) while it has been stated as an impossibility at Erh-li-t'ou. Smelting does not appear to have occurred in the vicinity of either assemblage. As far as the chemical analysis of the bronze can be compared dissimilarities are apparent. In addition, similar artifact types did not appear in the two assemblages.

The conclusions from this final comparison are that Erh-li-t'ou cannot represent the very earliest bronze production site in North China or in East Asia. The bronze produced is undecorated and simple in form and there are relatively few pieces in the assemblage but it does include two categories of socio-technic artifacts, one of which utilized the more advanced core technique of manufacture. It appears possible that earlier sites with flat, utilitarian items only may still appear and it may also be possible that sites with the earliest types of metalwork, hammered copper, still may be discovered in North China. Therefore, Non Nok Tha although also using the core technology was preceded by copper working and appears to be an earlier bronze assemblage than Erh-li-t'ou. However the differences apparent in the assemblages show that they are probably unrelated and independent assemblages and do not allow the assumption that only one of these areas was the site for the beginning of bronze technology in East Asia. The possibility exists for either indigenous development from external stimulus or separate invention with no outside stimulus of any kind for either area.

This study has demonstrated the existence of different technologies, different levels of social integration and different social contexts for bronze objects for all four early bronze assemblages. Thus it has also demonstrated that the beginning of bronze production did not have to occur in urban or state environments.



2. Andronovo Dagger
Form.
(Jettmar 1950:Pl.6)

1. Bronze daggers or knives from West Siberia of
earliest stage of metallurgical development
representing Western (Caucasian) types.
(Sulimirski 1970:301)

3. Andronovo
Axes (celts)
(Sulimirski
1970:286)

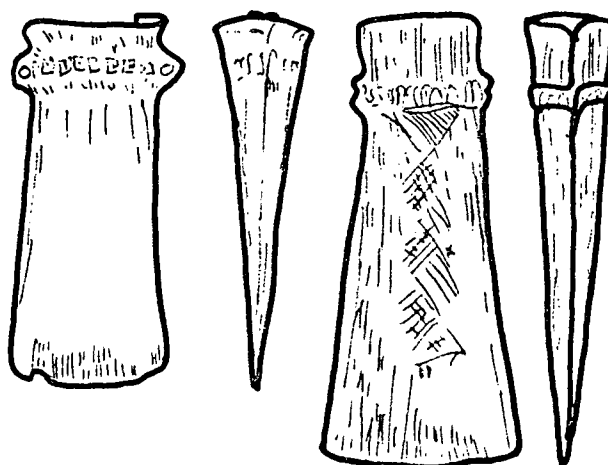
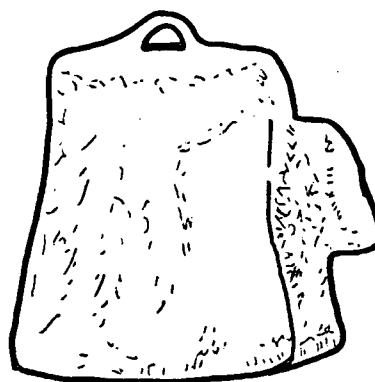


Figure 1. Minusinsk Artifacts



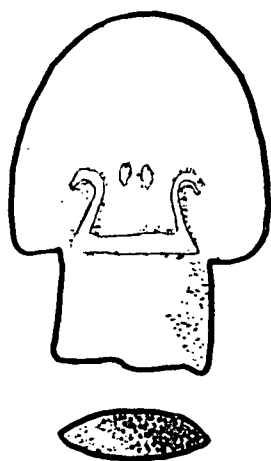
1.Knife



2.Bell

(Fang 1965:Pl.5)

Figure 2. Erh-li-t'ou Artifacts



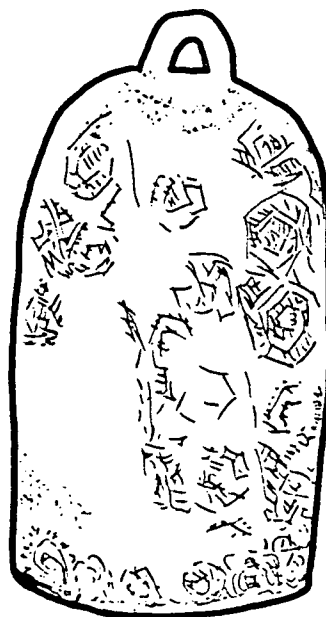
1. Axe



2. Axe



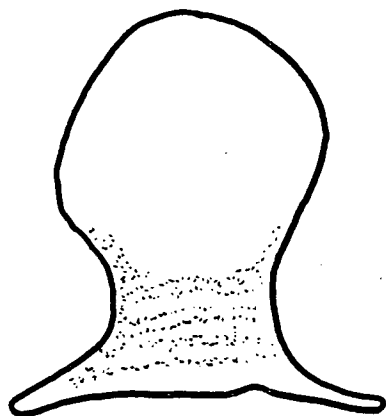
3. Dagger or Knife



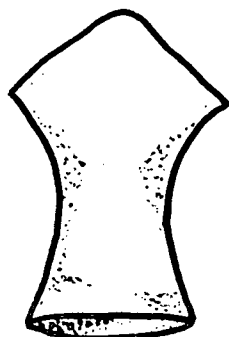
4. Bell

Figure 3. Ta-p'o-na Artifacts

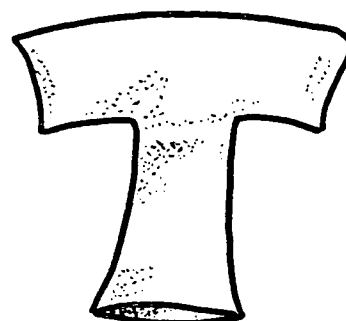
(Hsiung and Sun 1964:607-614.)



1. (Solheim 1967:899)

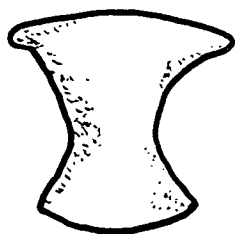


2. (Solheim 1968:61)

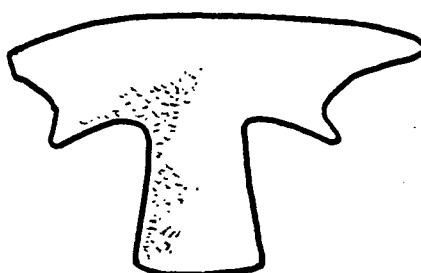


3.

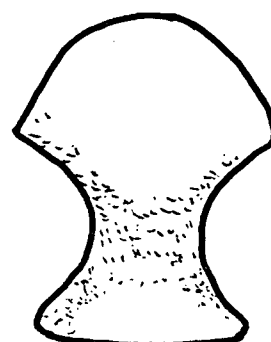
Mold shapes for axeheads



4.

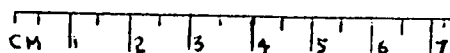
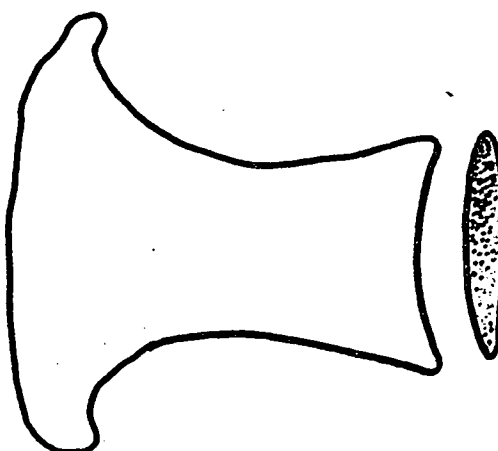


5.



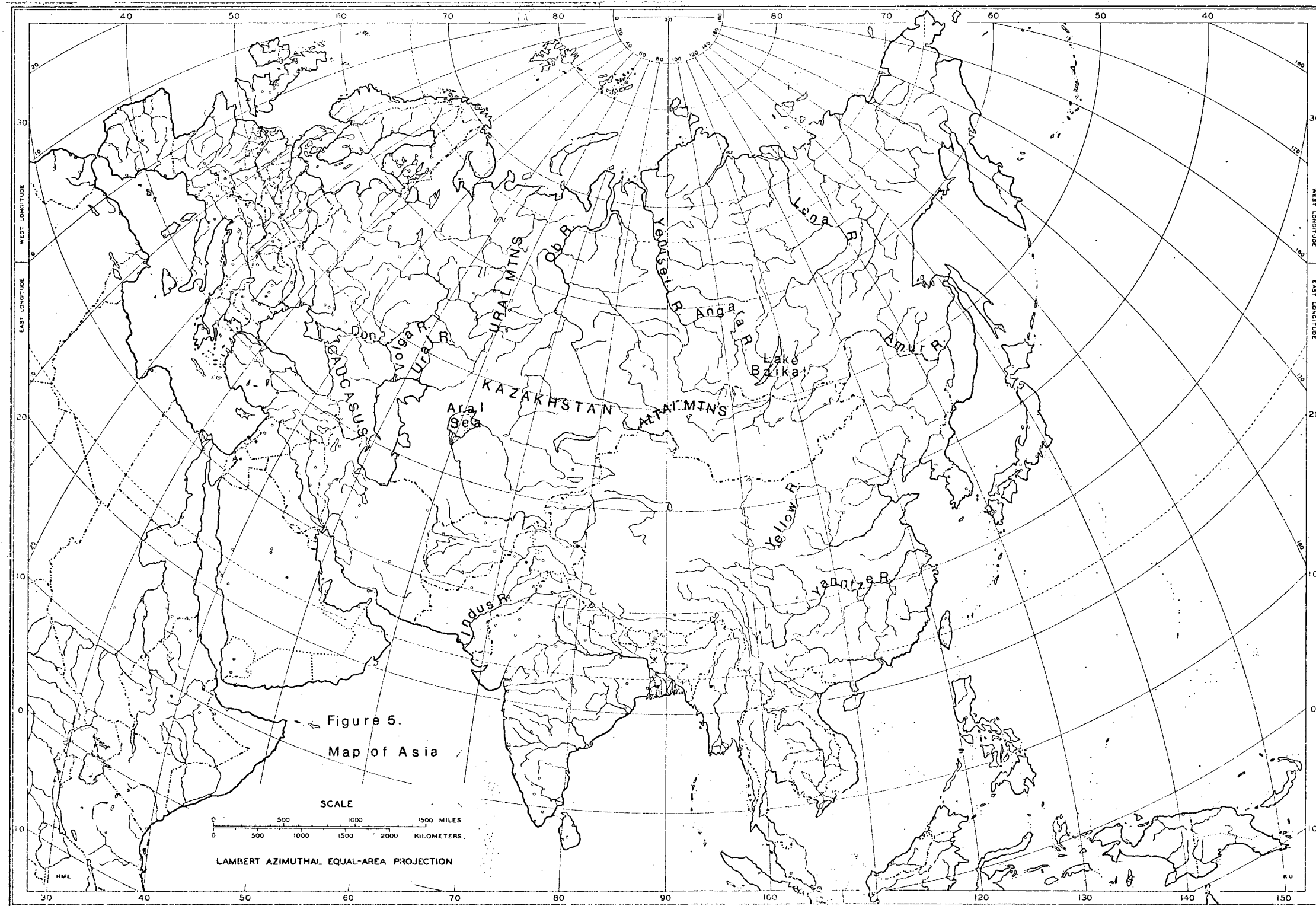
6.

(Solheim 1972:40)



7. (Solheim 1967:898)

Figure 4. Axes from Non Nok Tha





LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION
Figure 6.

BIBLIOGRAPHY

Aitken, M.J.

- 1970 Dating by archaeomagnetic and thermoluminescent methods. The impact of the natural sciences on archaeology. A joint symposium of the Royal Society and the British Academy. London: Oxford University Press, pp. 77-88.

Barker, H.

- 1970 Critical assessment of radiocarbon dating. The impact of the natural sciences on archaeology. A joint symposium of the Royal Society and the British Academy. London: Oxford University Press, pp. 37-45.

Barnard, Noel

- 1961 Bronze casting and bronze alloys in ancient China. Canberra: Australian National University. Monumenta Serica Monograph 14.
- 1967 The special character of metallurgy in ancient China. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: Museum of Fine Arts, pp. 184-204.
- 1972 First radiocarbon dates from China. Canberra: Department of Far Eastern History Research School of Studies. Monographs on Far Eastern History 8.

Bayard, Donn T.

- 1970 Excavations at Non Nok Tha, northeastern Thailand, 1968: an interim report. Asian Perspectives XIII: 109-143.
- 1971 An early indigenous bronze technology in North East Thailand: its implications for the prehistory of East Asia. Unpublished manuscript.
- 1972 Early Thai bronze: analysis and new dates. Science 176: 1411-1412.
- 1975 On Chang's interpretation of Chinese radiocarbon dates. Current Anthropology 16 (1): 167-170.

Befu, Harumi

- 1956 Yayoi culture. Mimeographed.

Binford, Lewis R.

- 1972 Archaeology as anthropology. Mark P. Leone (ed.), Contemporary Archaeology. Carbondale and Edwardsville: Southern Illinois University Press, pp. 93-101.

Bleed, Peter

- 1972 Yayoi cultures of Japan: an interpretive summary. Arctic Anthropology IX (1): 1-23.

Boriskovsky, P.I.

- 1966 Basic problems of the prehistoric archaeology of Vietnam. Asian Perspectives IX: 83-85.

Bronson, Bennet and Mark Han

- 1972 A thermoluminescence series from Thailand. Antiquity XLVI (182): 322-326.

Burleigh, R.

- 1973 The New Zealand radiocarbon conference. Antiquity XLVII (185): 54-56.

Caley, Earle R.

- 1967 Critical evaluations of published analytical data on the composition of ancient materials. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: Museum of Fine Arts, pp. 167-171.
- 1970 Chemical composition of Greek and Roman statuary of bronze. Art and technology: a symposium on classical bronzes. Cambridge, Mass. and London, England: M.I.T. Press, pp. 37-49.

Chang, Kwang-chih

- 1963 Prehistoric ceramic horizons in southeast China and their extension into Formosa. Asian Perspectives VII: 243-250.
- 1964 Prehistoric and early historic culture horizons and traditions in South China. Current Anthropology 5 (5): 359, 368-375 and 399-400.
- 1968 The archaeology of ancient China. New Haven and London: Yale University Press.
- 1973 Radiocarbon dates from China: some initial interpretations. Current Anthropology 14 (5): 525-528.
- 1975 Reply to Bayard (1975) On Chang's interpretation of Chinese radiocarbon dates. Current Anthropology 16 (1): 169-170.

Chard, Chester S.

- 1956 The oldest sites of Northeast Asia. American Antiquity 21 (4): 405-409.

Chard, Chester S.

- 1961 Time depth and culture process in Maritime Northeast Asia. Asian Perspectives V (2): 213-216.
- 1967 Prehistoric Japan: a survey of cultural development down to Late Jomon stage (c 2000 B.C.). Symposium: Early Chinese art and its possible influence in the Pacific Basin. New York City: Department of History and Archaeology, Columbia University. Mimeographed.
- 1974 Northeast Asia in prehistory. Madison: University of Wisconsin Press.

Charles, J.A.

- 1975 Where is the tin? Antiquity XLIX (193): 19-24.

Chase, W.T.

- 1974 Comparative analysis of archaeological bronzes. Archaeological Chemistry Advances in Chemistry Series 138: 148-185.

Cheng, Te-k'un

- 1960 Archaeology in China vol. II Shang China. Cambridge: W. Heffer and Sons.
- 1973 The beginning of Chinese civilization. Antiquity XLVII (187): 197-209.
- 1975 New light on Shang China. Antiquity XLIX (193): 25-32.

Coghlan, Herbert Henry (ed.)

- 1951 Notes on prehistoric metallurgy of copper and bronze in the Old World. Pitt Rivers Museum's Occasional Papers on Technology 4. London: University of Oxford Press.

Creel, Herrlee Glessner

- 1937 Birth of China. New York: Frederick Ungar Publishing Co. (fifth printing 1964).

Cushing, Daniel

- 1967 Principles of corrosion applicable to ancient metals and methods of identifying corrosion products. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: Museum of Fine Arts, pp. 53-65.

Derevianko, A.P.

- 1965 New data on the archaeology of the Middle Amur. Arctic Anthropology III (1): 136-141.

- Dougherty, Ralph C. and Joseph R. Caldwell
 1966 Evidence of early pyrometallurgy in the Kerman Range in Iran. Science 153: 984-985.
- Fang, Yu-sheng
 1965 Preliminary report on the excavation of the archaeological site of Erh-li-t'ou, Yen-shih in Honan province. K'ao-ku 5: 215-224.
- Fleming, S.J.
 1970 Authenticity testing of art ceramics by the thermoluminescence method -- some important examples. W.J. Young (ed.), Application of science in examinations of works of art. Boston, Mass.: Museum of Fine Arts, pp. 206-212.
- Fontein, Jan and Tung Wu
 1973 Unearthing China's past. Boston, Mass.: Museum of Fine Arts.
- Gettens, Rutherford J.
 1967 Joining methods in the fabrication of ancient Chinese bronze ceremonial vessels. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: 205-217.
- Gorman, Chester
 1971 The Hoabinhian and after: subsistence patterns in South-east Asia during the Late Pleistocene and Early Recent Periods. World Archaeology 2 (3): 300-320.
- Gryaznov, M.P.
 1969 The ancient civilization of Southern Siberia. New York: Cowles Book Co. Inc.
- Heekeren, H.R. Van and Count Eigil Knuth
 1967 Archaeological excavations in Thailand Vol. 1 Sai-yok. Copenhagen: Munksgaard.
- Hsia Nai
 1963a Archaeology in New China. Peking Review 6 (3): 13-19.
 1963b Recent archaeological work in China. Archaeology 16 (3): 176-182.
- Hsiung, Ying and Sun T'ai-ch'u
 1964 Excavations of a bronze coffin tomb at Ta-p'o-na, Hsian-yun, Yunnan province. K'ao-ku 12: 607-14.
- Izumi, Seiichi et al.
 1961 Symposium: recent archaeological studies on the culture history of Hokkaido. Minzokugaku Kenkyu 26 (1): 1-12 (English summary).

- Jettmar, Karl
 1950 The Karasuk culture and its South-Eastern affinities. Bulletin of Museum of Far Eastern Antiquities. Stockholm 20: 83-126.
- Kaneko, Erika
 1964 Japan. Asian Perspectives VIII (1): 24-68.
- Kao, Jen-tsun (ed.)
 1970 Masterworks of Chinese bronze in the National Palace Museum, Taipei. Taipei, Taiwan: National Palace Museum, pp. 96-99.
- Kidder, J.E.
 1956 Early Chinese bronzes in the City Art Museum of St. Louis. St. Louis: Washington University.
 1959 Japan before Buddhism. London: Thames and Hudson.
- Kim, Jeong-hak
 1972 The prehistory of Korea. Pusan National University. (Translated and edited from the Japanese (Kankoku no Kokogaku, 1972, Kawade Shobo) by Richard and Kazue Pearson. Manuscript.
- Kim, Jung-bae
 1975 Bronze artifacts in Korea and their cultural-historical significance. Richard Pearson (ed.), The traditional culture and society of Korea: prehistory. Occasional Papers of the Center for Korean Studies 3: 130-191. Honolulu: University of Hawaii.
- Kim, Won-yong
 1975 The Neolithic culture of Korea. Richard Pearson (ed.), The traditional culture and society of Korea: prehistory. Occasional Papers of the Center for Korean Studies 3: 61-111. Honolulu: University of Hawaii.
- Lamberg-Karlovsky, C.C.
 1967 Archaeology and metallurgical technology in prehistoric Afghanistan, India and Pakistan. American Anthropologist 69: 145-162.
- Larichev, V.E.
 1962 Neolithic settlements in Cis-Baikal (1957-1959 excavations). Arctic Anthropology 1 (1): 93-95.
- Li, Chi
 1957 The beginnings of Chinese civilization. Seattle: University of Washington Press.

- Li, Chi (ed.)
1970 Studies of the bronze ting-cauldron. Archaeologia Sinica New Series 4. Nanking, Taiwan: Institute of History and Philology Academia Sinica. (English summary: 97-103, 105, 123.)
- Li, Chung
1975 The achievements of the Chinese working people in metallurgical technique in ancient times. K'ao-ku 5: 259-263.
- Li, Chu-tsing
1973 Chinese art. John Meskill (ed.), An introduction to Chinese civilization. New York and London: Columbia University Press.
- Libby, W.F.
1970 Radiocarbon dating. The impact of the natural sciences on archaeology. A joint symposium of the Royal Society and the British Academy. London: Oxford University Press, pp. 1-10.
- Loehr, M.
1968 Ritual vessels of Bronze Age China. New York: Asia Society Inc.
- Loofs, H.H.E.
1974 Thermoluminescence dates from Thailand: comments. Antiquity XLVIII (189): 58-62.
- Maringer, John
1950 Contributions to the prehistory of Mongolia. Reports from the Sino-Swedish Expedition Publication 34 VII Archaeology. (Part 7, Vol. 7) Stockholm.

1963 Mongolia before the Mongols. Arctic Anthropology 1 (2): 75-85.
- Michael, Henry N.
1958 The Neolithic Age in Eastern Siberia. Translations of the American Philosophical Society 48 (2).
- Mongait, Alexander
1959 Archaeology in the U.S.S.R. Moscow: Foreign Languages Publishing House.
- Mourer, Cecile and Roland
1971 Prehistoric research in Cambodia during the last ten years. Asian Perspectives XIV:35-42.
- Ogilvie, Robert E.
1970 Applications of the solid state X-ray detector to the study of art objects. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: Museum of Fine Arts, pp. 84-87.

Okladnikov, A.P.

- 1959 Ancient populations of Siberia and its cultures. Cambridge, Mass.: Peabody Museum. (Russian Translation Series 1 (1)).

Pearson, Richard

- 1962 Dong-S'ou and its origins. Bulletin of the Institute of Ethnology of Academia Sinica 13: 27-50.
- 1967 The prehistoric cultures of East Taiwan. Asian and Pacific Archaeology Series 1: 25-31. Honolulu: University of Hawaii.
- 1973 Radiocarbon dates from China. Antiquity XLVII (186): 141-143.
- 1975 The prehistory of Korea: an introduction. R.J. Pearson (ed.), The traditional culture and society of Korea: prehistory. Occasional Papers of the Center for Korean Studies 3: 1-30. Honolulu: University of Hawaii.

Penniman, T.K.

- 1951 A note on specimens in the Pitt Rivers Museum illustrating cire perdue casting. H.H. Coghlan (ed.), Notes on the prehistoric metallurgy of copper and bronze in the Old World. Pitt Rivers Museums Occasional Papers on Technology 4: 119-120. London: University of Oxford Press.

Pittioni, Richard

- 1970 Addendum to Solheim's Spectro-analytical research on bronze from Northeast Thailand. Asian Perspectives XIII: 158-161.

Rowlands, M.J.

- 1971 The archaeological interpretation of prehistoric metalworking. World Archaeology 3 (2): 210-224.

Saurin, E.

- 1969 Les recherches prehistoriques au Cambodge, Laos et Viet Nam (1877-1966). Asian Perspectives XII: 27-41.

Savage, George

- 1968 A concise history of bronzes. London: Thames and Hudson.

Shih, Chang-ju

- 1955 Bronze casting in Yin dynasty. Bulletin of History and Philology of Academia Sinica 26: 95-129.

Shih Hsio-yen

- 1972 The study of ancient Chinese bronzes as art and craft. World Archaeology 3 (3): 267-275.

Slater, E.A. and J.A. Charles

- 1973 Rejoinder, archaeology and metal analysis. Antiquity XLVII (187): 220-221.

Smith, Cyril Stanley

- 1967 The interpretation of microstructure of metallic artifacts. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: Museum of Fine Arts, pp. 20-52.
- 1970 Discussion session 1.1. Art and technology: a symposium on classical bronzes, pp. 51-56.

Solheim II, Wilhelm G.

- 1963 Formos~~on~~^a relationships with Southeast Asia. Asian Perspectives VII: 251-260.
- 1967 Southeast Asia and the West. Science 157: 896-902.
- 1968 Early bronze in Northeast Thailand. Current Anthropology 9 (1): 59-62.
- 1969 Reworking Southeast Asian prehistory. Paideuma XV: 125-139.
- 1970 Northern Thailand, Southeast Asia and world prehistory. Asian Perspectives XIII:145-162.
- 1972 An earlier agricultural revolution. Scientific American 226 (4): 35-41.
- 1973 Remarks on the Neolithic in South China and Southeast Asia. Journal of Hong Kong Archaeological Society 4: 25-29.
- 1974 Reflections on the new data of Southeast Asian prehistory: Austronesian origin and consequence. Journal of Hong Kong Archaeological Society V. Manuscript.

Soper, Alexander

- 1966 Early, Middle and Late Shang: notes. Artibus Asiae 28: 5-36.

Sørensen, Per and Tove Hatting

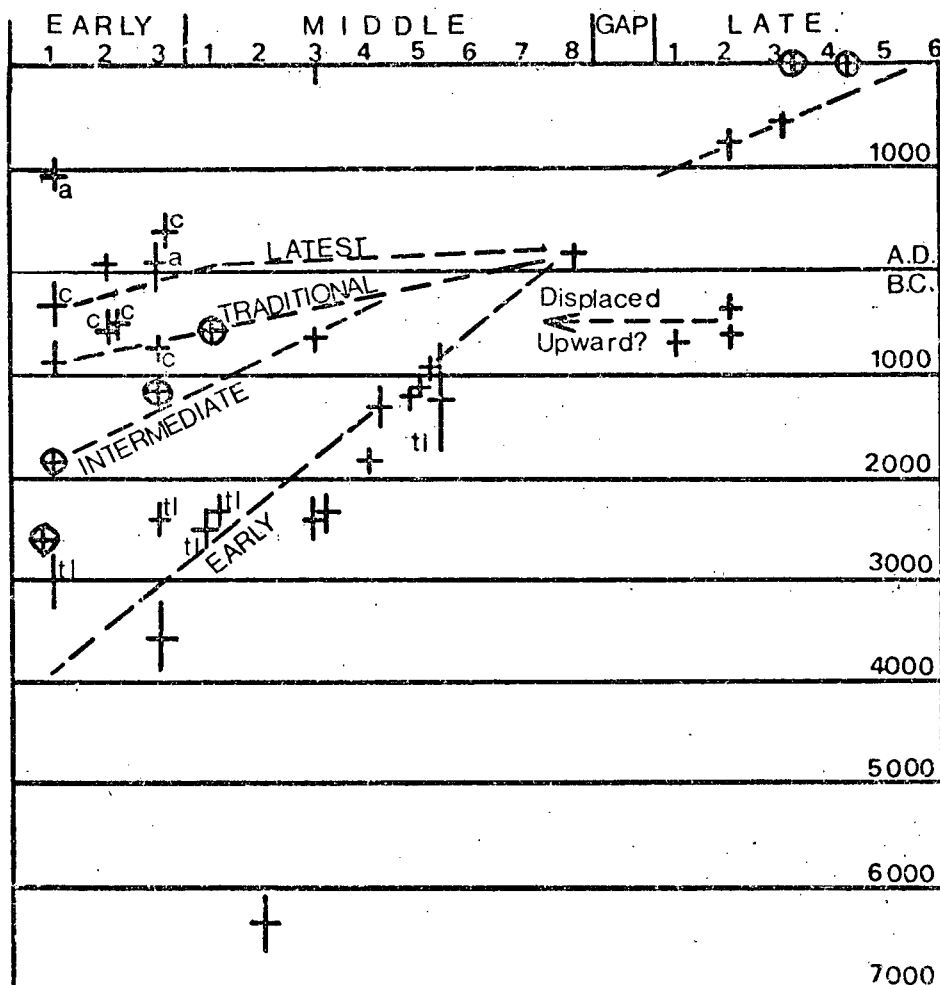
- 1967 Archaeological excavations in Thailand Vol. II Ban Kao. Neolithic settlements with cemeteries in the Kanchanaburi Province Part I: archaeological material from the burials. Copenhagen: Munksgaard.

- Steinberg, Arthur
 1970 Joining methods on large bronze statues: some experiments in ancient technology. W.J. Young (ed.), Application of science in examination of works of art. Boston, Mass.: Museum of Fine Arts, pp. 103-138.
- Steward, Julian H.
 1955 Theory of cultural change. Urbana: University of Illinois Press.
- Sulimirski, Tadeusz
 1970 Prehistoric Russia. London: John Baker Publishing Ltd.
- Takamiya, Hiroe
 1967 Archaeological work in the Ryukyu Islands, 1961-1965. Asian and Pacific Archaeology Series 1: 11-18. Honolulu: University of Hawaii.
- Voce, E.
 1951 Examination of specimens from the Pitt Rivers Museum. H.H. Coghlan (ed.), Notes on the prehistoric metallurgy of copper and bronze in the Old World. Pitt Rivers Museums Occasional Papers on Technology 4: 105-111. London: University of Oxford Press.
- Von Dwall, Magdalene
 1967 The Tien culture of South-west China. Antiquity XLI (161): 8-21.
- Watson, William
 1966 Early civilizations in China. London: Thames and Hudson.
 1971 Cultural frontiers in ancient East Asia. Edinburgh: Edinburgh University Press.
- Werner, A.E.A.
 1970 Analysis of ancient metals. The impact of the natural sciences on archaeology. A joint symposium of the Royal Society and the British Academy. London: Oxford University Press, pp. 179-185.
- Wheatley, Paul
 1971 The pivot of the four quarters. Chicago: Aldine Publishing Co.
- Yoshizaki, Masakazu
 1963 Prehistoric culture in Southern Sakhalin in the light of Japanese research. Arctic Anthropology 1 (2): 131-158.

Young, William J.

1970 Authentication of works of art. Art and technology: a
symposium on classical bronzes. Cambridge, Mass. and London,
England: M.I.T. Press, pp. 85-94.

APPENDIX ONE



Absolute dates from Non Nok Tha. a, apatite, c, collagen, tl, thermoluminescence; others charcoal. Circled dates are those thought to have been affected by modern contamination. Range shown is one standard deviation (Bayard 1975:168).