IRON AND SALT INDUSTRIES IN ISAN

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Isan is now a poor country. But it was once a rich and civilized country in the ancient times. Dense distribution of archaeological sites proves the existence of the economic basis that supported dense population and wealthy societies in northeast Thailand.

Recent archaeological surveys and excavations conducted by Southeast Asian and foreign archaeologists including the author suggest that prehistoric industries such as bronze and iron-working, and salt-making activities adaptive for the environment and the ecosystem in the northeast were the important background to support the prosperity and the urbanization of the ancient societies besides rice cultivation and forest products. Mekhong River and the Mekhong basin played important transportation route for the local economic centers.

This is a revised paper which was presented at the seminar in Bangkok in 1994.

1. Background

The northeast is a plateau called Khorat Plateau. This plateau is formed by the Khorat Mesozoic sedimentary rock. There was a sea in the Mesozoic more than one hundred fifty million years ago. The upheaval in the Tertiary period sealed the sea water in this area. Very thick rock salt layer that originates from the sealed sea water exists deep underground in the Khorat Plateau. The estimated amount of rock salt deposit is one trillion nine hundred and ten billion tons (Workman 1972:90-94). Another pebble layer that contains salt extends over a wide area several meters deep under the surface. Salt that dissolves in water from this layer comes up to the surface by the movement of the underground water, and then causes serious contamination and injury to the soil. Recent large scale deforestation causes much more serious damage to the agriculture in this area.

Another geological problem of the Khorat Plateau is infertile soil called the Mahasarakham formation unsuitable for agriculture. It consists of laterite that contains mainly iron and alumina.

Salt and laterite have been primary natural factors to impede highly productive agriculture in the northeast. Artificial factors added to natural ones to cause serious social problems. Technological development brought prosperity, population concentration, stratified society, chiefdom and civilization to the Northeast.

2. Prehistoric Industries

2.1. Iron-working

Metallurgy began in the late second millennium B.C. in Southeast Asia. I had supposed the date of birth of metallurgy in Southeast Asia at 1,200B.C. as terminus a quo on the ground of the typological study on stone Ko daggers (halberd) excavated from Phung Nguyen culture layer at some sites such as Lung Hoa in north Vietnam and from the royal tombs of the late Shang Dynasty in China (Nitta 1981, 1984). Recent archaeological discoveries in Vinh Phu Province, Vietnam provided a key to fix the date of the birth of metallurgy in Southeast Asia. Yazhang , Chinese ceremonial implements made of nephrite or jade mainly in Shang Dynasty, were discovered from the Phung Nguyen culture layer at Phung Nguyen and Xom Ren sites (Ha 1993:16-27). Chinese archaeologist, Wang Yongbo made a chronological order of yazhangs in China and Vietnam, and he estimated the type of yazhangs found in Vietnam around 1,100 B.C.(Wang 1996:55) The date of these Yazhangs settled the date when bronze metallurgy began in Southeast Asia. Many C-14 dates collected in northeast Thailand in recent years also support this date(Higham 1996). Metallurgy began in the late first millennium B.C. Prehistoric metallurgy and other productive activities such as salt-making developed into prehistoric industries in the second millennium B.C.

In northeast Thailand, there are many mounds that were constructed by the prehistoric and ancient people as like as tepe or tape in Southwest Asia. They are two kinds of archaeological sites that prehistoric people constructed for many generations by heaping the soil.

One is the shelter from the flood in the rainy season, and the other is the debris of some kinds of human activities such as prehistoric industries. The former is a habitation site, and the latter is an industrial one. Many industrial sites are distributed in northeast Thailand, especially in the Mun-Chi basin in the southern part of the Khorat Plateau. Many burnt sherds, burnt soil and clay, or much iron slag are scattered on the surface of the mound. These mounds are divided into two categories, iron-smelting sites and salt-making sites. According to the potsherds collected on the surface, many industrial sites belong to the Dvaravati and the Khmer periods. But recent archaeological excavations suggest that the two industries began very much earlier than those periods. They began in the first millennium B.C.

Iron-smelting industry or iron-working activity was very important for the economy of the northeast in prehistoric times. There are two different hypotheses on the origin of iron in Southeast Asia. One hypothesis is that the iron-smelting technology was introduced from China after the third century B.C. on the ground of the comparative study between the bimetal weapons found in Thailand, Vietnam and Yunnan. For example, the iron spearhead with bronze socket from Bang Chiang, northeast Thailand, the iron sword with bronze hilt from Dongson, north Vietnam and the iron sword with bronze hilt found at Shizhaishan cemetery, Yunnan that belongs to the Warring States period to the West Han Dynasty are classified into the same category of bimetal, bronze and iron tool. Furthermore, cast iron hoes and plowshares of which types were very popular after the Warring State period in China are usually found in north Vietnam. These facts mean that the iron technology was introduced from China after the Warring State period, that is to say, after the third century B.C. They say that bimetal tools were made in the earliest days when iron was first introduced and very rare product.

Another hypothesis is that the iron-smelting technology was independently invented in Southeast Asia by 500 B.C. because of the difference between the methods of iron-smelting technologies in Southeast Asia and China. The method in Southeast Asia is direct method, and that in China is indirect one. In Southeast Asia they produce wrought iron by using small furnaces and make iron implements by forging wrought iron, but in China they produce cast iron at first and then change cast iron to wrought iron or steel by heating and hammering, or decarbonizing. Chinese method is called indirect one. They say that a lot of C-14 dates associated with iron implements or iron technology which are earlier than 500 B.C. support this hypothesis. In China, two kinds of iron, cast and wrought irons were produced at the beginning of iron. Forged iron tools such as a lod and a ball were found in the tombs in the Spring and

Autumn period, and forged iron sward and knife, and a cast iron three-legged kettle were found in the same tomb in the late Spring and Autumn period in Chansha, Honan Province. Cast iron axes and forged iron knives were excavated from the tomb No.2717 in Loyang in the earliest Warring States period. Co-existence of two kinds of iron can be found at the birth of iron technology in the fifth century B.C. in China. After the Warring States period and the West Han Dynasty, casted iron implements for agricultural use were mass-produced by big private sectors and governmental factories.

At the moment it is too difficult to say when the iron production began and whether the iron-smelting technology was independently invented here or it was introduced from the outside of southeast Asia, for example China or India.

In 1990 I conducted the excavation at Ban Dong Phlong iron-smelting site. Ban Dong Phlong is situated at Ban Dong Phlong, Tambon Dong Phlong, Satuk District, Buriram Province. It is located south of the River Mun and about fifty km north of Buriram City. It is a big mound about 10 m high from the surrounding rice field level. It is surrounded by three moats and the earthworks.

A huge amount of iron slag and potsherds are found on the surface and the cliff of the mound. The western part of the mound was demolished by removing the soil for the road construction in 1987. Villagers also destroyed it to take the slag for the road pavement and to flat and level the slope of the mound.

Iron-smelting Activities at Ban Dong Phlong

The excavation exposed many structures related to the iron-smelting activities and the burials under the iron-smelting layers. Seven cultural layers were recognized. Seventeen iron-smelting furnaces, one dump pit for debris, one burnt wooden structure as a hut, many pitholes and seven human burials were revealed.

Seventeen furnaces were excavated at Ban Dong Phlong site. They belong to three different periods. Twelve C14 dates are available on the charcoals from Ban Dong Phlong. They were checked by Japan Isotope Association. Twelve dates are as follows.

All by 5568 h.y.

N-6158 : 2010±120 B.P. (60±120 B.C.) Charcoal collected in Furnace S4.

N-6159 : 2160± 85 B.P. (210±85 B.C.) Carbonized pillar of the clay wall of Furnace S5.

N-6160 : 2090± 85 B.P. (140±85 B.C.) Carbonized pillar of the clay wall of Furnace S5.

N-6161 : 2070±85 B.P. (120±85 B.C.) Carbonized pillar collected in the pit hole southeast of Furnace S5 in Layer 2.

N-6162 : 2120±175 B.P. (170±175 B.C.) Charcoal collected in Furnace S6.

N-6163 : 2040± 80 B.P. (90±80 B.C.) Carbonized pillar south of Furnace S6 in Layer 2.

N-6164 : 2260± 85 B.P. (310±85 B.C.) Carbonized pillar east of Furnace S8 in Layer 2.

N-6165 : 2050± 80 B.P. (160±80 B.C.) Charcoal collected in Furnace S15.

N-6166 : 2010± 95 B.P. (60±95 B.C.) Charcoal from the 6th layer in the subtrench. This sample is collected in the burial layers.

N-6167 : 2110±135 B.P. (160±135 B.C.) Charcoal from the 6th layer in the subtrench.

N-6168 : 2210±85 B.P. (260±85 B.C.) Charcoal collected in layer 2 at the southwest corner of grid A in the main trench.

N-6169 : 2210±80 B.P. (260±80 B.C.) Charcoal collected in layer 2 in grid A2 in the main trench.

According to C14 dates, the iron-smelting activities at Ban Dong Phlong site can be estimated during the third to the first centuries, mainly in the second century B.C. Typological study on the pottery between Ban Dong Phlong and Non Yang sites supports this estimated date. We found the same type of pottery in the iron-working layers at Dong Phlong as that found in cultural layer 3 to the lowest layer at Non Yang. They belong to the fourth to the second centuries B.C. (Nitta 1991; 12-15, pl.32)

The furnaces found at Dong Phlong are all shaft furnaces made with clay that were blasted by the piston bellows. Basically they resemble to those of the 6th and the 14th centuries that Pornchai Suchitta excavated at Ban Di Lung, Lopburi Province (Suchitta 1983:183-6). Metallurgical analysis of the iron slags collected from the furnaces at Ban Dong Phlong was carried by Prof.Isamu Taguchi at Department of Museum Sciences, National Museum of Japanese History. A preliminary report is available (Taguchi 1992). According to the analysis (Table 1 and 2), the slags were caused not from refining but from smelting by using not iron sand but iron ore. The sample No.4 collected at the bottom of Furnace S4 is very important. It is half-melted and half-deoxidized material that consists of some kind of nodules. CT scanning and electron microscopic analysis revealed the structure and the characteristics of this nodule. The tunic made of oxidized iron covers the core made of clay. This is a kind of iron nodule. They used the iron nodule as material. Iron nodules are distributed in large area in northeast Thailand and easily collected. The iron nodule was one of the important material to produce iron in Thailand.

Table.1 Metallurgical Analysis of Iron Slag and Melted Iron or Iron Nodules collected at Ban Dong Phlong

	FeO	SiO_2	Al_2O_3	MnO	CaO	MgO	K_2O	TiO_2	V_2O_3	CuO	P	S
No.1	50.60	35.36	12.79	0.00	0.70	0.00	0.55	0.00	0.00	0.00	0.00	0.00
No.2	53.88	34.92	9.96	0.00	0.86	0.00	0.38	0.00	0.00	0.00	0.00	0.00
No.3	57.77	31.68	9.59	0.00	0.69	0.00	0.27	0.00	0.00	0.00	0.00	0.00
No.4	53.79	35.68	9.01	0.00	0.30	0.70	0.29	0.00	0.00	0.00	0.22	0.00
No.5	60.08	30.65	8.79	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.17	0.00
No.6	21.12	66.33	4.20	0.01	2.15	1.13	3.66	0.00	0.00	0.00	1.19	0.21
No.7	42.92	42.55	13.26	0.00	0.68	0.04	0.55	0.00	0.00	0.00	0.00	0.00
No.8	58.79	34.74	6.15	0.00	0.14	0.00	0.18	0.00	0.00	0.00	0.00	0.00
No.9	47.75	42.38	4.03	0.00	3.77	0.00	2.06	0.00	0.00	0.00	0.00	0.00
No.10	73.58	21.39	1.49	0.12	1.57	0.93	0.03	0.00	0.00	0.00	0.41	0.21
No.11	49.87	40.13	6.62	0.07	1.64	0.14	1.53	0.00	0.00	0.00	0.00	0.00

(Metallurgical analysis was carried by Prof. Isamu Taguchi, Museum Science Department, National Museum of Japanese History, Sakura, Japan)

(No.1: Slag from Furnace 1-A, No.2: Slag from Furnace 1-B, No.3: Slag from Furnace 1-B, No.4: Slag from Furnace 1-H, No.5: Iron Nodule from Furnace 4, No.6: Melted Iron Nodules and Clay Wall from Furnace 5, No.7: Slag from Tap pit of Furnace 5, No.8: Slag from Furnace 6, No.9: Slag from Furnace 8-A, No.10: Slag from Furnace 8, No.11: Slag from Furnace 16.)

Table 2. Results of the Analysis

Sample	Result of Analysis
No.1	Smelting slag from iron ore
No.2	Smelting slag from iron ore
No.3	Smelting slag from iron ore
No.4	Smelting slag from iron ore
No.5	Iron nodules
No.6	Melted iron nodules and clay wall
No.7	Smelting slag and clay wall
No.8	Smelting slag from iron ore
No.9	Smelting slag from iron ore
No.10	Semi-deoxidized iron ore and clay wall
No.11	Smelting slag from iron ore

I summarize the iron production at Dong Phlong. They produced wrought iron by the direct process by using iron ore and iron nodule as material, and charcoal as fuel and deoxidizer. The iron-working activity at Dong Phlong was carried around the second century B.C.

2.2. Salt-making

Salt-making activities were also very important for the economy of the northeast. Salt-making sites are mainly distributed in the Mun-Chi basin and in Nong Han region around lake Kunpawapi in the northern part of Isan. These areas overlap the area of rock salt deposits each other, and belong to the driest zones in northeast Thailand of which rainfall registers 1,000 to 1,250 mm a year. The sites are located at the areas easy to gain water along small rivers, ponds or lakes. Not only archaeological sites but also ethnographic sites of salt-making are distributed in these areas.

The test excavations at Bo Phan Kan and Non Dua near Suwannaphum in Roi Et Province exposed the remains of salt-making activities. At Bo Phan Khan, a lot of charcoal as debris of fuel and two small pits plastered by clay to contain brine were uncovered (Higham et al.1971:10. Higham 1977). One C14 date collected from Bo Phan Kan shows they began salt-making here in the fifth century B.C. This date is now the earliest one of salt-making activities in the Khorat Plateau. At Non Dua, the pottery was dominated by a coarse and thick ceramic used to boil brine in preparing salt. Furthermore concentrations of charcoal with pits and plastered surfaces which were interpreted as the remains of industrial salt extraction. Salt-making was vigorously pursued during phase 2 at Non Dua, which can be dated a couple of centuries earlier than 1 B.C. This means that the people at Non Dua exploited to the saline environment and concentrated on salt-making activity during the late first millennium B.C.

Fine Arts Department excavated another salt-making site at Ban Non Phia near Bo Kathin, one of the center of salt-extraction in the upper Chi valley. This site is also a big mound.

The excavation of salt-making mound was conducted by the author in the upper Mun basin in order to make clear when they began it and how they produced salt.

Non Tung Pie Pone site is situated at Ban Ngiu Mai, Tambon Ban Ngiu Kao, Bua Yai District, Nakhon Ratchasima Province. It is located about 50m north of the main road Rote 202 between Amphoe Bua Yai and the intersection of Ban Sida in the Upper Mun basin. It is a mound that consists of two connected small mounds. It measures about 5.5m high and 120m long in N-S and 75m in E-W directions. The mound is surrounded by the barren land and the rice paddy field. In dry season, salt comes up to the surface in the dessert land that surrounds the mound. The surface of the area is covered with salt as if it was covered with snow. Many sherds of roughly made cord-marked pottery are scattered on the surface and the skirts of the mound. Almost of them are heavily burnt and eroded. No potsherds that belonged to the historic age were found. This suggests the mound is a prehistoric salt-making site.

Another salt-making mound, Non Sung, which means "high mound", is located about 250m west of Non Tung Pie Pone. Non Sung was destroyed by the road construction. Many salt-making potsherds are scattered on the remained mound and in the collapsed one. Some sherds of salt-making pottery can be collected on the surface. Local salt-making activity is still actively run in dry season by the local people in the area around the sites. These modern salt-making systems and techniques in this area do not use a trunk for filtration but a clay-walled pit dug in the ground. They look as the structures excavated at Non Tung Pie Pone. Fortunately I came across the scene that one 65-years-old woman, Khun Mo and her 75-years-old husband began to work to make salt near the site at the end of our excavation. Ethnography of local salt-making activity was also collected near the site in December 1991 (Nitta 1992;66-7).

Excavation of Non Tung Pie Pone

Nine phases for salt-making activities were exposed by the excavation. Archaeological structures consist of water storage tanks, containers for the filtration of brine, furnace for boiling salty water and other kinds of furnaces, pots installed near the structures and pit holes of temporal dwellings or arbors for the workers to take rest.

The water storage tank is that of storing water drawn from the well or other sources of water for the efficiency to filter the salty water. The walls and the floor are thinly plastered with clay to prevent the water leak. Its plan is square or rectangular. One example is pentagonal. The central part of one wall was broken. The trough for the filtration of brine is used to collect brine after filtering. Soil containing the crystal of salt is put into the trough and then water is poured into it. Then salt dissolves into the water and brine comes down from the bottom of the trough. The walls of the trough are made with clay mixed with rice straw or some kinds of grass as temper. The walls are burnt to make hard. One facility of the filtration usually consists of one pair of troughs or one set of three troughs that line in N-S direction. The central part of the south wall of many troughs is broken. In some cases, one pit or one pot in the pit is set in front of the central part of the south wall. This pit or pot is to store the brine that drips from the trough. Furnace to boil the salty water is used to crystallize salt by boiling and evaporating. Only one furnace to boil the brine was found in the north section of the trench. It has no special structure. Many potsherds of salt-making pottery were found scattered on the burnt soil. Two other kinds of furnaces were excavated in the trench. One is a furnace for cooking, and the other is for unidentified use. Some sherds of ordinary pots and salt-making ones were found in the former, and in the latter were found many sherds of salt-making and ordinary pots. A complete salt-making pot was found fallen into the latter. Several pit holes were found near the furnace. These pitholes were those of temporal dwellings for the salt-making workers or arbor for the worker to take a rest. According to the structures excavated in the trench, this area was mainly used for the filtration and the collection of brine from the soil that contains salt. The excavation of the mound from the top to the bottom revealed the stratigraphy of the major ten layers. The stratigraphy shows that there are some small low mounds piled by the soil dumped after the filtration and that the flat ground for the salt-making activities at the site was made by putting the soil and the burnt clay into the hollow between the small mounds and flattering the ground. This means that the big mound of Non Tung Pie Pone was artificially composed by the dumped soil after the filtration of the salt-making activities. A salt-making pot that was found in the tenth layer, the bottom of the mound, proves that the site was composed of the dumped soil after the filtration.

Almost of all the findings at Non Tung Pie Pone are cord marked salt-making pottery. They are simple bowls with round bottom. They are made by paddle-and-anvil technique. They measure about 20 to 30 cm in diameter and about 15 cm deep. One pot that looks very much like a salt-making pot was found in Test Pit No.3. It is modified the rim as a spout. It was used to ladle the water. Ordinary pottery was also collected. They are cord marked vases and pots. Several sherds of Pimai Black were collected in the layers. Long bones and ribs of big animals such as ox and deer, many snails and shells were also collected. They were food for the workers.

Estimated Age of Salt-making Activity at Non Tung Pie Pone

Only one C14 date is available. I could not collect enough charcoal to date by C14. One sample of charcoal was collected in the seventh layer. This sample may be caused from the fuelwood. The seventh layer was sandwiched by the layers that contained the salt-making structures. It was dated by Japan Isotope Association in 1992.

N-6308   1740±185 B.P. (210±185 AD.) (5568 h.y.)

The sherds of Pimai Black Ware also suggests the age of the salt-making activities here. I estimate the age of salt-making here around the second to third century AD.

There can be seen no typological difference between the pottery from Phase 1 to Phase 9, the last phase. If one phase means one season of salt-making activity, nine phases show no more than nine salt-making seasons. So the salt-making activity was run at Non Tung Pie Pone for a very short term. The mound was formed in a short time, for example, for about ten years around in the first to the fourth century AD.

Salt-making Activities at Non Tung Pie Pone

Ethnography of local salt-making is as important as archaeological excavation of salt-making sites. I have collected ethnographic data in the northeast (Nitta 1989, 1996). According to the excavation and the ethnographic data collected near the site, the method of salt-making can be reconstructed as follows. The land suitable for making salt is selected and occupied by the people. Prehistoric salt-making required large extent of saline land, easy water supply and enough amount of wood as fuel. The trough used to filter and the water tank were plastered with clay. The trough has a bamboo spout at the bottom of the central part of the south wall. Rice husks and some bundles of long grass leaves were put on the bottom of the trough as filter and waterway. Collected sand that contains salt is put into the trough. Water is ladle from the well near the site, and it is poured on the sand in the trough. After the filtration, brine comes down from the spout into the pot installed in the pit outside the wall of the trough. After finishing the filtration, the soil in the trough is dumped away near the site, and piled like a small mound behind or near the salt-making spot. The brine collected in the pot is boiled on the furnace for a long time, and then salt begins to crystallize. The salt-making facilities are repaired or reconstructed on the same spot of last season. This results the dumped soil becomes high mound after many seasons.

2.3. Iron and Salt around Isan

Iron working began during the end of the Spring and Autumn period and the early years of Warring States period, so as to say in the fifth century B.C. in China. Two kinds of iron, wrought and cast iron, were put into practical use. In the Warring States period cast iron was mass-produced to make farming implements, for example, hoe spade, at big factories run by private sectors. Salt was also extracted from the time immemorial, and became one of the biggest industries in China in the Spring and Autumn period. There were three different salt-making methods in China, boiling sea water in the coastal regions in Shantong and other Provinces, boiling saline water in the lake in inland areas, and boiling brine from the well in Sichuan and Yunnan.

Governments taxed on iron and salt. According to the biographies of the rich men in China in Shiji written in 97 B.C., which was a Chinese History on the time from the mythological age to the reign of Emperor Wu, some of the billionaires engaged in the iron working and the salt-making business. West Han government changed the financial policy and enacted the monopoly system on iron and salt in 119 B.C. because of its financial crisis. Iron and salt were profitable business for the government. Han government settled 50 iron factories and management centers(Tieguan), and 36 salt extraction factories and management centers (Yanguan) in its territory. The iron factories and centers were owned and runned by the government. On the other hand the salt factories and centers were runned by the private factors, and all of the salt produced were purchased by the government. Salt continued to be one of the most important commodities for the governmental finance from the West Han Dynasty to the 20th century.

ECAFE published the report of the distribution of mineral resources of the lower Mekhong basin and adjacent areas (Workman 1972). According to this report, main iron ores distribute in north Loei, Lopburi and Nakhon Sawan Provinces in Thailand, Phnom Deck, Preah Viher Province and surface debris in Stung Treng Province in Cambodia, Xieng Khouang Province in Laos, and Bac Tay, Quang Tri, Quangnam-Danang Province in Vietnam. There may be more iron deposits of small scale that prehistoric or local people have worked at various times. We have to consider the existence of iron deposits of much smaller scale than the ores mentioned above.

In Southeast Asia except Thailand, no prehistoric iron-smelting nor salt-making sites have been excavated so far. Only in Sarawak some iron-smelting sites were excavated by Tom Harrison, but they belong to the historic age, from the Tang to the late Yuan or the pre-Ming Dynasties (Harrisson et al. 1969).

In Vietnam a lot of iron implements were found from the burials. Ha Van Tan said that iron implements in Vietnam were casted (Ha 1991). But two kinds of iron implements, forged and cast iron implements existed in north Vietnam in the late first millennium B.C. Weapons such as spearhead and dagger are forged, and hoe spade and socketed axe are casted. Casted hoe spades and axes are typologicaly as same as those of Han style. Some of the cast iron implements were imported from South China, especially Lingnan. According to Shiji and Hanshu, History of the West Han Dynasty, Han prohibited to export iron implements to Nanyue (Nam Viet) in 187 B.C. King of Nanyue got angry with new policy of Han Government and ceased to be contendent with being the tributary of the Han Dynasty. Furthermore he attacked Changsha, a kingdom of the Han Dynasty. This episode and the archaeological findings mean that many cast iron implements, especially farming tools and axes, were imported from China, and imported cast iron implements played important role in agriculture in Nanyue including north Vietnam. As mentioned above, Han Government settled fifty iron factories and centers in its territory in 119. No iron factories and centers were distributed in Lingnan. No distribution of the iron factories and centers explain that iron ore mines were very rare in Lingnan, or the people in Lingnan lacked the knowledge of iron-mining nor iron-smelting technologies. Huang supposes that Nanyue did not have its own iron-smelting technology, and was supplied iron ingots from central China (Huang 1996. 60). At the moment I partly agree with his hypothesis because iron slag were excavated at some sites in Dongson period in north Vietnam.

Unfortunately it was not reported whether the iron slag was made by smelting, refining or forging.

In Bac Bo region some iron implements were excavated from pirogue coffins outside Red River delta. Nine iron hoe spades of Han style were associated with a socketed bronze spearhead in Burial 3 at Xuan La that belongs to the Xin Dynasty, early in the first century AD. He possessed imported cast iron agricultural tools and bronze spearhead probably made in Vietnam. According to the co-existence of imported iron implements from China and bronze tools made in Vietnam in the first century AD. when bronze tools disappeared except ornaments in northeast Thailand, they had not yet produced enough quantity of iron in north Vietnam.

In coastal areas of central and south Vietnam, forged iron implements were found from jar burials as funeral goods in Sa Huynh Culture. Sa Huynh Culture is distributed from Hai Van Pass to Ho Chi Minh City. As an advisor, I joined very important excavations of Sa Huynh jar burial cemeteries in Hoi An in 1993 and 1995. In central Vietnam. The excavations conducted by Hoi An Vestiges Management Office uncovered many forged iron tools from the burial jars at Hau Xa I, II and An Bang sites in Hoi An, Quangnam-Danang Province from 1993 to 1995 (Nguyen Chi Trung et al 1995a, 1995b; Tran Van An et al. 1995). They consist of socketed spades of digging tool, socketed axes, flat axes, knives, Han style knives with ring, sickles and so on. On the ground of typological studies, these burial jars belong to the first century AD. Sa Huynh people used wrought iron to make iron implements.

In the south, many forged iron tools were excavated from Giong Ca Vo and Giong Phet jar burial cemeteries of Sa Huynh Culture, Can Gio District, Ho Chi Min City (Nguyen Kim Dung et al. 1995; Nguyen Thi Hau 1995; Dang Van Thang et al. 1995). At Giong Ca Va, 4 rings, 6 spearheads, 3 knives, 4 chisels and many fishing hooks were found associated with the burial jars. They are all forged iron tools. Many bone and shell tools such as hoes and digging tools and bronze tools such as axes and digging tool spades were associated with iron tools. One C-14 date, 530±50 B.C., that is incredibly too old is available from Giong Ca Vo site. According to the typological studies on the jars and stone and glass ornaments such as lingling-O, double-headed earrings and carnelian beads from the jars, Giong Ca Vo and Giong Phet sites belong to the first century AD. In south Vietnam, they had continued to use bone, shell and bronze tools as before in the first century AD. after accepting iron tools though a concentration of iron slag was found in the cemetery at Hang Gon site (Saurin 1973) which was dated late the first millennium B.C. This explains that iron had not come into wide use in south Vietnam.

Cast iron hoe spades that are usually found in the north are not included in the assemblage of iron implements in Sa Huynh Culture. Iron spades of Sa Huynh Culture resemble to those of northeast and west Thailand. Sa Huynh people produced iron by themselves or imported iron from outside. We have no exact archaeological data on the iron-smelting activities in Sa Huynh Culture.

As a whole, Bac Bo area imported cast iron implements from China and did not produce enough deal of wrought iron during the late first millennium B.C. between the early first millennium A.D. The coastal areas of central and south Vietnam may have had some amount of wrought iron production but may have been supplied a large amount of iron by northeast Thailand by the river route.

Salt production in China during the Han Dynasty was carried in a large scale as mentioned above. Many Chinese documents refer to the salt extraction and stamped tiles of the tombs in the East Han Dynasty show the scene of the salt extraction working. Two tiles discovered in Chengdu Sichuang Province were stamped the scene of salt extraction workings which provide many information on it. The method of taking the brine is different between northeast Thailand and southwest China. There were many well to brow up the brine in Sichuan and Yunnan Provinces. Shiji and Huayangguozhi said that the brine well in Sichuan were exploited by Li Bing, Governor of Sichuan after his appointment by Chin King in 255 to 251 B.C. Of course local people might have used the brine well long before the period of Li Bing. They used wood and natural gas to boil the brine in Sichuan and Yunnan Provinces. According to Chinese documents such as Huayangguozhi and Bowuzhi written in the third century A.D., natural gas was discovered in 67 B.C. and began to be used to boil the brine (Ling et al. 1987:379-386). On the contrary, no archaeological information is available on the salt extraction in Southeast Asia except northeast Thailand. Salt extraction by boiling sea water might be carried in some of the coastal regions in Southeast Asia. Furthermore they may have used sea water itself to cook instead of making salt. Unfortunately we have no archaeological remains of the activities at the moment. Only some Khmer inscriptions refer to salt. Khmer government highly taxed on salt and the official named as kamsten turbac control salt. The price of salt was higher than rice. Salt was expensive and important for the state finance even in historical times (Nitta 1989). Salt was more difficult to get and more expensive in prehistoric times.

2.4. Iron and Salt in Isan

Ban Dong Phlong is the earliest iron-smelting sites so far excavated not only in Thailand but also in Southeast Asia. Pornchai Suchitta excavated another iron-smelting site, Ban Di Lung in Lopburi Province that belonged to the 6th and the 14th centuries. Some archaeologists refer to the usage of iron nodules to produce iron in ancient Thailand. They used them at Dong Phlong. In the Khorat Plateau, extensive bed of wide distribution of sedimentary soils covered with laterite concretion or laterite that contain low percentage of iron (Boosner 1986;249-61), and iron nodule that contains low percentage of iron, for example about 60% at Dong Phlong, was possible to be used for iron-smelting. There are many iron deposits that contain less than 60%of iron in Southeast Asia (Workman 1972:11) and they are possible to make iron. The Khorat Plateau has inexhaustible iron deposits. The same situation can be recognized at Ban Krabuang Nok in Nakhon Ratchasima Province (Indrawooth and others 1990). The iron-smelting industry exploited the environment of the northeast.

Many sites that contain the remains of iron-smelting or working were so far found in northeast Thailand. In the upper Mun basin, many iron-smelting furnaces were found at the southeastern edge of the mound of Noen-U-Loke site, and many iron implements such as ax or digging toll and ring were also excavated associated with the stretched burials at the Phimai pottery period (Wichakana 1991). At Ban Krabuang Nok, much iron slag reveals local iron-smelting during 300 B.C. and 200A.D. Iron implements were collected at a lot of sites in this area. Iron slag also distributes at many sites in the Chi valley. For example, iron fragments and slag were found in the basal layer which can be dated after 400 to 300 B.C. at Non Chai, Khon Kaen (Bayard et al. 1986). A huge mound of iron slag is situated at a Buddhist temple, Ban Nong Sapung, Kosumpisai District, Khon Kaen Province. Red-slipped pottery and red-painted on buff pottery were surface-collected on the mound. This shows that iron-smelting was carried at this mound late in the first century B.C. Sites where much iron slag was distributed are located along the road from Khon Kaen to Chum Pae. Iron was also produced at Ban Chiang Hian in the middle Chi Valley. Iron implements or fragments were collected in many site in the Khorat Plateau. All of them are wrought iron, and smelted and forged tools.

Iron had spread widely before the Christian era in the northeast. Iron production was considerably in large scale and iron had already spread widely in the Khorat Plateau late in the first millennium B.C. We can easily understand that many iron-smelting factories had to be run before the Christian era in northeast Thailand because many iron-smelting sites are distributed not only along the River Mun, but also along the Chi River and around Loei mountains.

Salt production was also exploited to the geological and environmental conditions in the northeast. Very thick rock salt deposits that originated from the sealed sea water exist deep underground in the Khorat Plateau. Another pebble layer containing salt extends over a wide area several meters deep from the surface. Salt dissolves in the water from this pebble layer and comes up to the surface by the movement of the underground water. The people exploited to this environment. Higham excavated Bo Phan Kan salt-making site in Roi Et Province and estimated the salt-making activity began in the fifth century B.C. (Higham 1977). Salt-making began in the fifth century B.C. and developed to be run as an
industry by exploiting to the environment in the Khorat Plateau by the first century B.C. There are some reason why the people began to make salt here. They had to intake sodium that was indispensable to live by having salt as they had rice as main food. Rice lacks sodium. Salt was also much demanded to make preserved foods. As animal protein, they usually eat many kinds of freshwater fish besides big games such as deer and boar in the northeast. Much salt was required to preserve the fish as salted fish and salty fish guts for a long time. They could not import the salt from China, largest center of the salt production in East Asia, nor from the coastal regions. They had to produce salt by themselves. The areas were limited where the salt was made in prehistoric times. Salt was not produced everywhere in Southeast Asia, even in the coastal regions. Salt-making needs thick brine, dry weather and enough supply of wood as fuel and vessel to boil salty water. There were not many regions that satisfied these conditions. The Khorat Plateau was one of rare regions that satisfied the condition of salt-making. The salt brought profits to the Khorat Plateau later.

The development of rice cultivation, iron-smelting, bronze casting and salt-making strengthened the economic background and then increased the population of the northeast. Rice, salt, iron and bronze were much in demand not only in the Khorat Plateau but also in Southeast Asia. Salt was for the stabilization of food and livelihood, iron for weapons and tools including farming tools, and bronze for ornaments and prestigious goods such as bronze drums. The products were transported by the river routes. The people accumulated wealth by the production and the export of them.

3. Chiefdom, Drum and Social Tension

In the late first millennium B.C. chiefdoms appeared on the economic and political development in the Khorat Plateau. Chiefs accepted and wanted to have bronze drums as their prestigious treasures or regalia.

Eight bronze drums were so far found in the Mekhong basin. Five came from Laos, Laos Drum from near Pakse (Goloubew 1929;42-5), Nelson Drum from Pakse or Champassak (Parmentier 1932;172-3), Sane Drum from Sane Island near Khong Fall (Doer 1993: Sorensen 1994: Nitta 1995) and two drums from Savannakhet (Parmentier 1932;173-4). Three are from the Khorat Plateau, Don Tan Drum from Don Tan Islet in Mekhong River (Nitta 1994), Chi Thwang Drum from Ban Chi Thwang (Na Nakhonphanom 1989), Ubon Ratchathani Province, Na Pho Tai Drum from Ban Na Pho Tai (Damrikul et al.1980;11), Ubon Ratchathani Province. All of them are Heger 1 type. Three of which were found in Champassak, such as Laos, Nelson and Sane Drums, belong to the earliest subtype of Heger 1 drums. Don Tan Drum has the motives of stylized birdmen on the top, and has four frog statuettes and the motives of parallelograms and facing triangles on the tympanon. The motives of Don Tan drum show it can be classified into the middle type of Heger 1. Chi Thwang and Na Pho Tai Drums are late type of Heger 1.

We have few information on the site characteristics where the drums were found. Laos Drum was found in the rice field along the road from Pakse to Ubon Ratchathani. No information is available on how the drum was found in the rice field. We have nothing to understand the site where Nelson Drum was unearthed.

We have some information only on Don Tan and Sane drums. According to the villager that I met at the site in 1987, two drums, big and small, were found from the tomb with other funeral goods, such as bronzes, glass beads and clay rollers. The burial was about two meters deep from the surface. The burial goods are similar to those from Ban Chiang. Almost of all the findings were brought to the Suan Pakkard Palace Museum in Bangkok. They belong to late phase of Ban Chiang culture. Don Tan site is distributed on the farmyard of the Thai territory and a small islet of the Lao side. The former was habitation area and the latter was graveyard for the society of Don Tan. Dan Tan drum was buried as one of the burial goods at the cemetery.

Sane Drum was laid upside down on four bricks in the sand layer. The drum was found 50 cm deep under the layer that contained the potsherds one meter deep under the water level. Nothing but a brick was found in the drum. It is very difficult to understand whether the site was a burial or other ceremonial or magical one.

Other drums in Southeast Asia offer some important information on the site where they were collected. For example, six drums from Ombah cave, Kanchanaburi Province, west Thailand, were put on near the boat coffins as funeral goods (Sorensen 1988;99-100). The drums found at Khao Kwak cave, Ratburi Province, south Thailand was associated with sherds of thin bronze bowl, glass beads and others, which resemble to those that were found at the cemetery of Ban Don Ta Phet, Kanchanaburi Province. Two drums of the earliest type are collected from Thailand (Nitta 1990;605-608). Ban Chiang Drum has a painted pottery attached on the inside of the tympanon, offering stand of the late type of Ban Chiang pottery. This painted pottery was used as funeral goods. This means that the drum was also put into the burial as a burial good associated with the painted pottery. Bronze drums were buried into the tombs from the time when they were accepted into the Khorat Plateau.

Kampong Sungai Lang Drum from the Malay Peninsula was found upside down in a boat coffin as a funeral good (Peacock 1965). Heger 1 Drums excavated in China are also funeral goods, containers of cowry shells used as burial good and coffin.

It is no doubt that many drums except some examples used as ceremonial goods were buried as funeral goods into the tombs. Bronze drum was chief's treasure for the prestige. After his death, he brought his drum into his own tomb as the chief's status symbol.

Heger 1 drums in the Mekhong Basin are distributed at the key point of the river transportation. Going upstream Mekhong from the river-mouth, we arrive at the border between Laos and Cambodia through Stung Treng. There are Khong Falls near the border. The Mekhong River transportation is interrupted at the falls. We have to land here once, unload the cargoes, change the boats, ship the cargoes again at the upstream of the falls and sail upstream. Sane island where Sane Drums was found is situated near the important position of the river. Pakse is located at the junction of two important rivers, Mekhong, the main river route in Southeast Asia, and Mun, the most important river in the Khorat Plateau that flows west to east and joins Mekhong. Pakse commanded the transportation to the Khorat Plateau, and to the middle and the upper reaches to Savannakhet, Vientiane, Luang Prabang, and Yunnan.

Champassak is the most important region in south Lao. There is a reason why Champassak became a political, economic and religious strongpoint in the Khmer Period.

Savannakhet, where Savannakhet Drums were collected near, and Mukhdahan, where Don Tan Drum was excavated near, are the pair port towns and the strategic and cross points of the river transportation and the land transportation between Quang Tri, important port city in Han Dynasty, and the Khorat Plateau. Savannakhet and Mukhdahan area is the strategic point of the river transportation and the traffic between the seashore and the inland.

Ban Chi Thwang where the drum was collected is near the junction of Mun and Chi Rivers. The two rivers are the most important ones in the Khorat Plateau. Chi flows from northwest to southeast and joins River Mun near Ubon Ratchathani. Khong Chiang District where Ban Na Pho Tai belongs is located near the mouth of River Mun. River Mun joins the Mekhong here.

Heger 1 drums in the Mekhong Basin are distributed at important point of the transportation and the traffic such as the junction of the rivers, the river-mouth, the interrupting point, the cross point and so on. Champassak, Savannakhet - Mukhdahan, Khong Chiang, Ubon areas are all important places of the transportation and the traffic. If they command these points, they will have economic and political power.

In the Khorat Plateau iron production was intensively run by using the iron nodules that were inexhaustibly deposited there by the third to the second century BC. Furthermore salt-making activity was also carried by exploiting the ecosystem in the Khorat Plateau. Iron and salt were rich products of the Khorat Plateau as well as the forest products. Iron-smelting and salt-making activity stations mainly concentrated in the Mun and Chi Basins (Nitta 1989, 1991, 1992). The development of prehistoric production activities in northeast Thailand strengthened its economic basis. Strategic villages such as Non Yang (Nitta 1991) in Surin Province, which is located at the left bank of River Mun, were constructed to protect the river transportation along the main rivers such as Mun and Chi. They are situated at the important point along the rivers, and have some protective facilities such as a fence and a ditch. Non Yang village was protected by the construction of wooden fence around it. They watched and protected the transport of the products from the Khorat Plateau to the outer world by using river routes such as Mun, Chi and Mekhong. Mekhong River is the most important artery of transport to connect the inner and the outer worlds. Bronze implements from Ban Chiang in northeast Thailand and those from Dongnai culture in the Dongnai basin which is located near the mouth of Mekhong River in south Vietnam show their inter-relations between two cultures by the Mekhong River route. Local powers in Ubon and Pakse commanded the transport between the inner and the outer world. Some big mound sites were recently excavated such as Karn Luang site in Ubon Ratchathani. They played key roles in the field of transport and commerce.

By as late as the third century B.C., local powers were born in Ubon and Pakse and their vicinities to command the river transport and traffic in the Mekhong Basin. Their chiefs accepted Heger 1 bronze drums as their treasures to express their prestige. The drums were buried as burial goods with their owners after they died. The chiefs could have very big drums because they had big economic and political powers by commanding the river transport and the most important strategic points in the middle Mekhong Basin.

04. Concluding Remarks

Northeast Thailand was prosperous by producing not only rice but also mineral ores such as copper and iron, bronzes, iron tools and salt. People gathered to live along the main rivers such as Mekhong, Mun and Chi Rivers. There were many political groups in the northeast, of which chiefs wanted to have bronze drums as their own prestigious goods. Strong points were constructed along the important transportation routes. Bronze drums were found at such points. Many small chiefdoms were coming into being in the late first millennium BC. There existed social tension among them. They had to protect their own villages by constructing the defensive installation in such social condition.

Many chiefdoms and kingdoms were born in Southeast Asia after the Christian era. Population pressure became bigger at various villages and chiefdoms. They resolved social problems by expanding the villages. The villages were surrounded by expanded moats. Big moats and earthworks were constructed around the habitation area. These moats are for not only protection but also hydraulic control.

In the first century B.C., some kinds of defensive installation were constructed such as ditch and fence. We can see the good example at Non Yang site in Surin Province. Non Yang village was protected by the wooden fence. Economic and social development based on rice cultivation and prehistoric industries influenced the social systems and caused tensions among the villages and chiefdoms in the northeast.

The people in the northeast exploited to the environment unsuitable for the agriculture, accumulated wealth by exporting iron and salt.

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