NEW RESEARCH ON THE BEGINNING OF USING ZINC IN CHINA

(With 2 text-figures)

By H. T. CHANG (章鴻釗)

(*Geological Survey of China, Peking*)

In my former articles published in this Bulletin§ and in Science§§ (Chinese), I have attempted to show that the early possible date of using zinc in China can be traced since Han Dynasty (201 B.C.—200 A.D.), and that *lu kan shih* (爐甘石) is the source of zinc, *pai shi* (白鉛) recorded in Sung Shih (宋史) is zinc, *lien* (連 or 鍊) recorded in Shih Chi (史記) and Han Shu (漢書) may be a zinc ore, and, therefore, *la* (鑞) used in the Chin, Suih and Tang times also seems to contain zinc. At that time my researches were made mainly from the literature. Recently some new data become available through the cooperation of Mr. Wang-chih-tien (王季點), Vice-Director of The Chemical Laboratory under the Ministry of Agriculture and Commerce, who kindly undertook the analyses of a number of ancient coins supplied by me. The results of these chemical analyses can not fail but to throw much new light on the problem.

I.

In order to classify the meaning of *lien* (連), it is best to analyse the coins made by Wang Mang (王莽 9-22 A.D.). For it was he who combined *lien shi* (連錫) with copper in coinage [see Shi Ho Chih (食貨志) in annals of West Han]. There are now 20 kinds of coins still preserved and identified as made in Wang-mang's time.

They are:

ta pu huang tsien	大布黃千	*ta chuan wu shih*	大泉五十
tze pu chiu pei	次布九百	*chuang chuan ssu shih*	壯泉四十
ti pu pa pei	弟布八百	*chung chuan san shih*	中泉三十
chuang pu tzi pei	壯布七百	*you chuan erh shih*	幼泉二十
chung pu lu pei	中布六百	*yiao chuan i shih*	幺泉一十

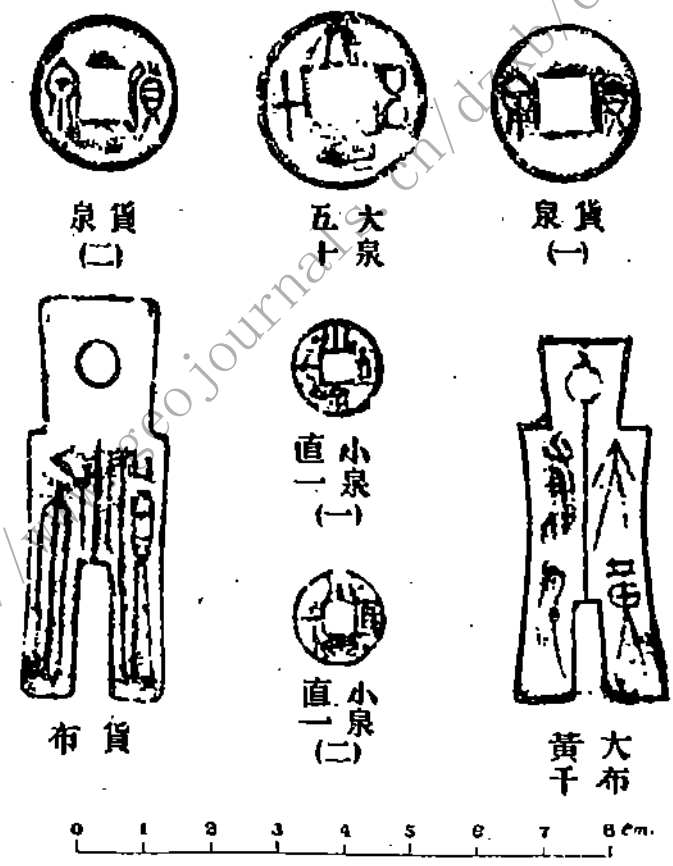
§ Bull. Geol. Soc. China, Vol. II, No. 1-2, pp. 17-27, 1922.

§§ Science (Chinese), Vol. VIII, No. 3, pp. 233-243, March, 1923.

chia pu wu pei	差布五百	*siao chuan chih i*	小泉直一
hsu pu ssu pei	序布四百 漢書序作厚	*i tao ping wu tsien*	一刀平五千 漢書平作直
you pu san pei	幻布三百	*chieh tao wu pei*	契刀五百 漢書契作契
yiao pu erh pei	幺布二百	*ho pu*	貨布
sio pu i pei	小布一百	*ho chuan*	貨泉

I sent for analysis six kinds of these coins which are all with only one possible exception[3], recognized by connoisseurs as the genuine ones made at Wang-mang's time. Besides these coins are sold now at too low price to be falsified with profit.

The following figures are of the five genuine ones:



3. *chuang chuan ssu shih* (貯泉四十) being doubted whether it is a genuine one.

The following shows the percentage of metals in Wang-mang coins, as obtained from the analyses made under the supervision of Mr. Wang.

Coins / Metals	ta chuan wu shih 大泉五十	ho chuan 貨泉	siao chuan chih i 小泉直一	chuang chuan ssu shih[3] 壯泉四十	ta pu huang tsien 大布黃千	ho pu 貨布	ch'ieh tao[4] 契刀
Cu	86.72	77.53	89.27	90.33	89.55	83.41	81.13
Sn	3.41	4.55	6.39	0.02	4.71	6.86	6.96
Pb	4.33	11.99	0.37	0.48	0.62	0.54	6.17
Zn	4.11	3.03	2.15	6.96	1.48	0.84	1.01
Fe	0.13	1.46	1.50	0.55	3.56	0.47	1.39
Total	98.70	98.56	99.68	98.34	99.01	98.12	96.66

From the above table, the amount of Pb is not proportional to Zn, the latter being sometimes more in amount. Therefore Zn can not have been carried unintentionally as impurity in Pb. On the other hand, the sums of Cu and Pb are from 89.52 to 91.31, and those of Cu, Pb, and Fe are 90.42 to 93.93. The same constancy is also somewhat maintained in the sums of Sn and Zn: (5.19—8.54). Therefore it is highly probable that Pb and Fe are carried in as part of the copper ore. Sn and Zn ores are taken together as a counterpart. Now the Annal of Han (漢書, Han Shu) tells us:

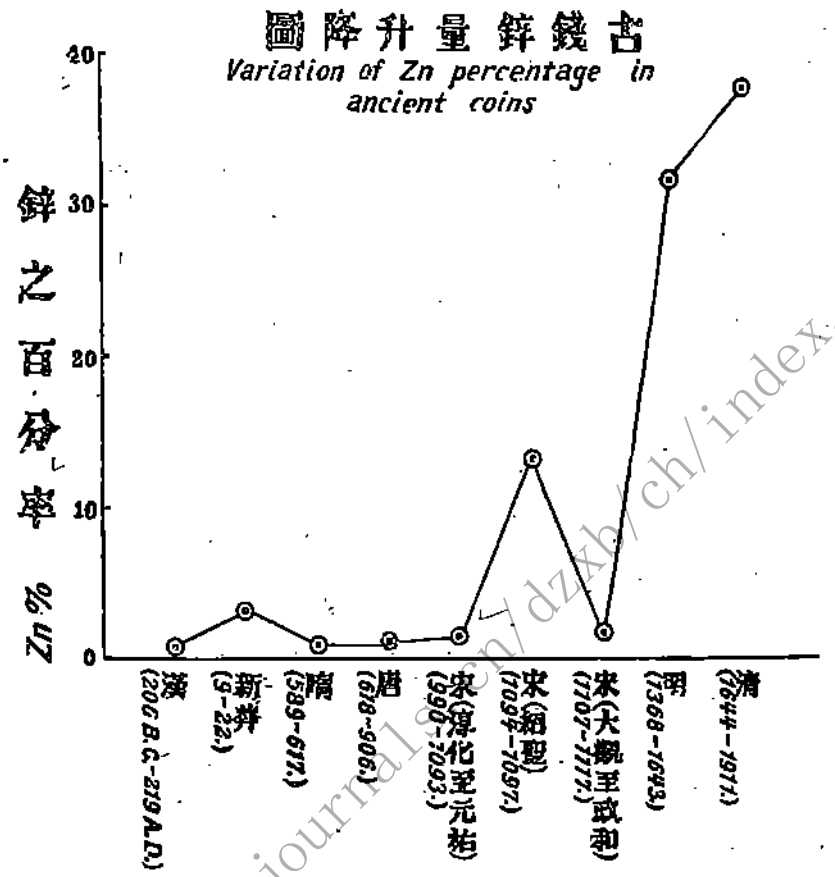
> "The coins of Wang-mang's time are made of copper with *lien hsi* (連錫) mixed in it."

Undoubtedly copper constitutes the essential part in coins. *Lien-hsi*, a term of two characters connected together, seems that zinc and tin are counted as one metal. Then *lien* can be no other than zinc.

In the following diagram[5] the larger amount of Zn used in Wang-man's time is clearly shown:—

---

3. See p. 126 footnotes.
4. The result of this anaysis (of *ch'ih tao*) is received by me much latter than the rest. Therefore it is not used in calculating the average in the following diagram. However, the difference can not be large, and the main feature is not affected.
5. This figure is compiled from the results of analyses published in Science Vol. 6, No. 11, Vol. 7, No. 8, Vol. 8, No. 8 and those obtained by Mr. Wang-chih-tien.



II.

For further illustration of *pai shih* and *la* in addition to what I have written in my former papers, following quotations from old literature may be of significance:

In Wang-ta-yuan's (汪大淵) Tao Yi Chi Lo (島夷誌畧), Vol. I:—

"The country, Tan Ma Ling (丹馬令), producing good quality of *pai shih*, used it in matrimonial ceremonies".

In Sung Shih (宋史):—

"Tan Mei Liu produces Rhinoceros (犀), elephants (象), and *t'ou shih* (鋀石). In the third year of Hsian Ping (咸平) tribute were made of *t'ou la shih*, (鋀鑞石), each 100 catties"

In Shen-tseng-chih's (沈曾植) Kuang Cheng (廣証):—

"Tan Ma Ling is the same as the country Tai Mei Liu in Sung Shih."

In Wai-yuan's (魏源) Hai Kuo Tu Chih (海國圖志), chapter 30:—

"Tan Mei Liu is the modern Eastern Indies".

T'ou is an alloy of Cu and Zn. *La* is also doubted to contain zinc. Since Tan Mei Liu produces *t'ou* and *la*, why then the *pai shih* that was produced from the same country should not be zinc!

III.

Mr. Wang-chin (王琎), Professor of the South-East University, in an article in Science (Chinese)[6] attributed the high percentage of zinc in Shao-sheng (紹聖 1094-1097 A.D.) coins of Sung dynasty to private mints and coinages in which *t'ou shih* was used. But private mints had been prevailing long before that time. The fact that the amount of Zn is just half of Pb and Pb is half of Cu, can not be overlooked as accidential occurrence. Since the people then smelted *lu kan shih* (*i.e.* smithsonite) to produce *t'ou* (鍮), then they can also recover zinc from the same. From the analysis also we now know it clearly that *pai shi* is zinc.

Mr. Wang-chin also was of the opinion that whereas according to the law in Tang dynasty Sn shall occupy 2% in coinage its actual percentage is much higher because of Sn brought in as a part of *la*. *Lien* and *la*, according to Mr. Wang-chin, are alloys of Pb and Sn and have no Zn. But by comparing the percentages used by Mr. Wang himself, I reached at quite a different conclusion from his.

Percentages of Kai Yuan (開元) coins of Tang dynasty.

Percentage of Elements	According to the annals of Tung	According to the 7 annuals of Sung	Analysis published in Science, Vol VI, No. 11.
Cu	83.5	66.0	70.06
Sn	2.0	13.0	12.69
la	14.5		
Pb		21.0	12.27
Zn			1.1
Fe			trace

6. Vol. VIII. No. 8.
7. The percentages here quoted by me as well as by Mr. Wang, however, can not be regarded as those actually used in Kai Yuan's time. They were taken in the Sung time attempting to make coins as near to Kai Yuan coins as possible. But the attempt, whether successful or not, is not recorded. (Science, Vol. IX, No. 9)

From the above table it seems more probable that the high percentage of Sn may come from the Cu which is supposed pure in Tang time. The sum of Cu and Sn comes very near to the amount of the supposed Cu, and the sum of Pb and Zn, very near to that of *la*.[8]

Further more the use of *la* is still seen in Japanese literature such as *yin la* (銀鑞 or silver and *la*) is an alloy of silver and zinc. Other zinc alloys are *yeng la* (硬鑞), *chung la* (中鑞), *tzao la* (早鑞),[9] their source though is uncertain, but their meaning is quite near to that used in Tang dynasty.

IV.

In November, 1923, Mr. R. P. Hommel kindly wrote to me, after he had read my paper on this problem. He based his opinion first from L. G. Wilkinson's work on ancient Egyptians and said that the Egyptians and probably the Romans used zinc before the Christian era. Then he quoted Galen (131-201 A. D.) who himself witnessed in Cyprus the use of Cadmia ($ZnCO_3$) to make pompholyx (the flower of zinc). Hence Mr. Hommel suggested to compare Chinese discovery of zinc with the further western countries.

Wang-mang's time (9-22 A. D.) is the beginning of the Christian era. The sources of *lien* used at that time can not be located. In the early Han Time, Wu Ti (147-84 B. C.) communicated with Turkestan, but not so far as to Egypt and Roman.

Previous to Wang-mang, Ching-ti (景帝,六年 191 B.C.) decreed those making false gold to be executed.[10] Lao Ching (婁敬, about 201-192 B.C.) and Huai-nan-wang 淮南王 about 105 B.C.) were said to have made false gold as medicine. Its exact meaning can not be ascertained but it might be quite nearly to the alloy of zinc and copper; for in the Han time brass (黃銅) is also called gold (黃金).[11] Thus the alloy of Cu and Zn might have long been known in China.

---

8 Science (Chinese) Vol. IX, No. 9.
9 See Mineral Industry (in Japanese) Vol. I. No. 2: Kamiyama's Alloys of Precious Metals.
10 Tsien Han Shu (前漢書), Ch. V.
11 See my "Translation of Laufer's Sino-Iranica" pp. 55. Memoir of the Geol. Surv. of China, Series B. No. 3, 1925.

V.

Laufer[12] said that in the annals of Sui dynasty (580-618) it is recorded that Persia produces *t'ou shih*. Persian language has *tutiya* for brass. Therefore *t'ou shih* is derived from *tutiya*. Thus smelting zinc does not begin in India, nor China; but in Persia. *T'ou shih* appears in Ching Chu Sheng Shui Chi (荆楚歲時記). Therefore in Sasanian period in Persia smelting is very prosperous at least as early as 6th century A. D.

But from my research, the term, *t'ou shih*, appears in still earlier works, such as Shih Yih Chih (拾遺記) by Wang-chia (王嘉, about 350-394 A. D)

In Buddhistic literature, *t'ou shih* is also recorded.

(1) A passage of A Nan Ssu Tze Ching (阿南四字經) translated by Chih-chien (支謙) of Wu (吳 222—230 A. D.) reads as follows:

世人疑惑 Man is weak,
心存癡倒 and ignorant,
自欺自誤 being dupe of himself
猶以金價買鍮銅也 just as taking *t'ou tung* for gold.

(2) In the Saddharmapundarika Vol. I. translated by Chiu-mo-lo-shih (鳩摩羅什) of Hou Chin (後秦) in the period 397—400 A. D. there is the following passage:[13]

鍮鈬赤白銅 T'ou shih, red and white copper,
白鑞及鉛錫 White *la* and lead-tin,
鉄木及與泥 Iron-wood and clay,
或以漆膠布 or with varnished cloth,
嚴飾作佛像 To make ornaments of Buddha idols.

12 See Laufer's Sino-Iranica: pp. 509-510.

13 This translation seems to have mentioned more materials than the original sanscrit, because the Chinese text is here written all in sentences of five characters and the translator had to add some things in order to complete the sentences. Thus T'u (鍮) and Hsih (鈬) form the first category; red and white copper, the second; Puiln (白鑞), lead and tin, the third; iron and wood, the fourth and clay, the fifth. Thus understood the Chinese translation conforms essentially to the sanscrit. See the writter's Chinese translation of Sino-Iranica, pp. 116-117.

Baron A. von Staël-Holstein has kindly shown me the original Sanskrit verse[14] in the Miao Fa Lien Hua Ching (妙法蓮華經) mentioning the five kinds of material to make Buddha idols and the French translation made by Burnouf.[15] The five kinds of materials are:

1. tâmra.....cuivres
2. kamsa .....bronze
3. sisa.....plomb
4. loha.....fer
5. mrid.....terre

In the order of Chiu-mo-lo-shih's translation *t'ou shih* (鍮鉐) seems to be *tâmra*. The sounds are nor far from each other. According to the translation of Chih-chien, the existence of *t'ou shih* in India seems to be before the third century. But whether the place of production and occurrence can be relied upon to determine the priority of using zinc is still questionable.[16]

14 Saddharmapundarika pp. 50–51 Edited by Kern and Bunyia Nanjio.
15 Burnouf: Lotus de la bonne loi, nouvelle edition, tome I, p. 33.
16 See my "Translation of Laufer's Sino-Iranica" pp. 46–60, 115–118.