LEAD ISOTOPE STUDIES ON ANCIENT BRONZE DRUMS OF GUANGXI CHINA

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ABSTRACT

A study has been reported on $^{206}Pb/^{208}Pb$ and $^{207}Pb/^{206}Pb$ ratio variations in ancient drums and Cu-,, Pb- ores from Guangxi, China and can indicate that the Cu- and Pb- bearing ores for making the Beiliu and the Lingshan type drums were taken from Tongshiling of Beiliu County and its vicinity, that were not only ancient sites for smelting the copper ores, but possibly also for casting the bronze drums. Some of the Lengshuichong type drums have abnormal Pb isotopic ratios, which means that they were made of special ore sources, one of the possibilities is that the ore material or the drums were transported from South- East Asia to Guangxi Province, because they have been excavated there too.

Keywords: **Ancient drums** **Lead isotopic ratios** **Ore sources**

I. INTRODUCTION

Since the pioneer paper of " Isotope studies in ancient lead" was published in 1967[1], the isotopic applications of lead to studies on ancient bronzes[2] including copper mirrors[3,4], coins[4,5], glass[6,7], colours, ceramic glaze[8], etc. have been developed in the world. Some researchers[9] have used oxygen and carbon isotopes to study Greek marbles, a kind of building material, and to search where it could have come from. The isotopic ratios of the elements in ancient objects can indicate their distribution, self- relation, and connection with the ore sources. Many significant results have not only provided new knowledge for reconsideration of argumentative questions in the long history, but also for opening a new approach to studies on manufacture, trade, transportation, and the cultural exchange among ancient societies.

We have been studying lead isotopes, chemical composition, and physical properties of ancient objects since 1984. The principles of lead isotopic method with single stage model, the advantages and disadvantages of the method are described in our paper[10]. We have determined the provenances of West Zhou bronzes, excavated in Yu Guo Tombs, Shanxi Province, China. The lead isotopic ratios showed that one group of the bronzes could be made by local raw material, while the other by ores

possibly transported from Tonglushan, Hunan Province. The experimental fact indicated that the ancient manufacture, transportation, trade and cultural exchange between the imperical court of Western Zhou Dynasty at Xian city (now) and the princedoms (Chu State) at Hunan Province (now) flourished in the early times[11].

Bronze drums are representatives of the historical culture of the minority people living in Southern China, such as Yunnan, Guizhou, Guangxi and Guangdong Provinces. About 1400 ancient drums since early Spring- Autumn Dynasty and Warring States Period (700—400 B.C.) to Ming- Qing Dynasty (1368—1828 A.D.) have been found in China so far. The earliest drums of the Wanjiaba type (700—400 B.C.) in the world were excavated in Yunnan. Even in South- Eastern Asia, such as Vietnam, Laos, Cambodia, Burma, bronze drums were also found. The lead isotopic studies on the ancient drums can be helpful to reveal the cultural exchange among ancient minorities, China and foreign countries, and to understand ancient manufacture, technique, mining development, and so on.

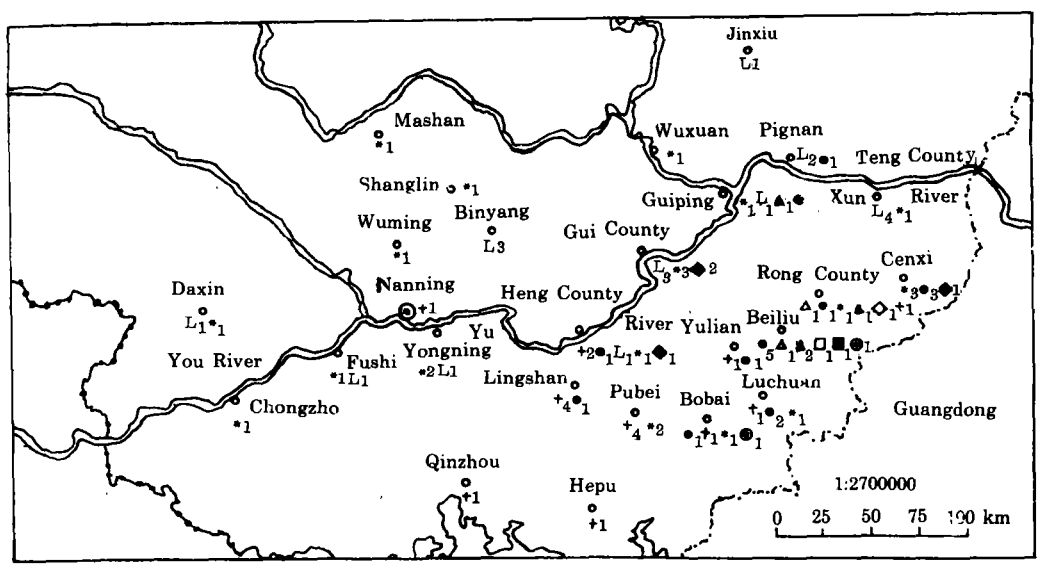

Fig.1 Sampling sites of Guangxi Province, China

● Beiliu type's drums + Lingshu type's drums *L* Lengshuichong type's drums

△ Ancient Cu ingot ▲ Ancient Cu ores □ Ancient Cu slag

■ Blast pipe * Pb- Zn ores ◆ Galena

◇ Ancient Pb ingot ❀ Sn placer O Local county ⊙ Capital city

The experimental methods were briefly described as follows. The samples were dissolved by $HClO_4$- HNO_3, then, the lead in the solution was purified and enriched by electrodeposition[12]. The lead isotopic ratios were determined by a Mass Spectrometry of VG—354 model, which can simultaneously detect 4 lead isotopes ^{204}, ^{206}, ^{207}, and ^{208}Pb.

The variation coefficents of all the samples for $^{206}Pb/^{204}Pb$, $^{207}Pb/^{206}Pb$, and $^{208}Pb/^{206}Pb$ were corresponding to 0.05%, ≤0.01% and ≤0.01%, respectively. The data of the lead ratios were also normalized by reference of NBS 981. The chemical composition was analysed by atomic absorption and electron probe methods. The precision of the methods was ≤ 1%.

Three types of ancient drums have been used for this study. First is the Beiliu type drums, about 150 of which have been excavated in China so far, while about 128 ones in Guangxi located in Beiliu, Rong, Cenxi, Yulian, Luchuan, etc. Counties. (Fig.1), in particular, 43 drums in Beiliu. The largest drum in the world, so called "Drum King" with the face diameter of 166 cm, the height of 67.5 cm and the weight of 300 kg, was also unearthed in Beiliu County.

Second is the Lingshan type drums located in Lingshan, Pubei, Heng, Luchuan, etc. Counties. There are 71 drums found in China, while 68 in Guangxi. It can be seen in Fig.1 that the distribution of the Lingshan type drums overlaps in many areas with that of the Beiliu type drums.

Table 1

The chronology of three types' drums from Guangxi, China

Type	Early stage	Middle stage	Late stage
Beiliu[19]	Eastern Han Dynasty		Tang Dynasty
Lingshan[19]	Eastern Han Dynasty		Tang Dynasty
Lengshuichong[18]	Eastern Han Dynasty —Southern Dynasties	Southern Dynasty - Tang Dynasty	Yuan Dynasty - Ming Dynasty

Table 2

Data for the bronze drums of Beiliu type from Guangxi, China

No.	Sample No.	Unearthed site	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	Cu(%)	Sn(%)	Pb(%)
1	- 34	Beiliu	18.460	0.84788	2.0986	88.68	8.60	0.96
2	- 35	Rong County	18.347	0.84716	2.0874	75.65	14.39	5.57
3	- 55	Luchuan	18.468	0.84802	2.0953	90.56	6.52	0.97
4	- 60	Yulian	18.103	0.85354	2.1075	86.02	11.2	0.22
5	- 115	Lingshan	18.358	0.84459	2.0883	69.42	16.16	21.5
6	- 146	Cenxi	18.487	0.84452	2.0945	87.34	9.49	0.49
7	- 156	Beiliu	18.544	0.84422	2.0929	74.21	22.19	0.66
8	- 161	Beiliu	18.570	0.84201	2.0877	88.95	7.62	0.35
9	- 163	Heng County	18.584	0.84342	2.0926	80.10	10.98	3.70
10	- 308	Beiliu	18.322	0.84813	2.1011	97.26	0.28	0.41
11	- 139	Beiliu	18.412	0.84915	2.1014	78.3	18.82	0.26
12	- 140	Bobai	18.566	0.85198	2.1165	69.61	12.0	12.0
13	- 157	Cenxi	18.811	0.84852	2.1118	77,71	19.1	0.66
14	- 143	Pingnan	18.364	0.85815	2.1177	72.5	7.50	13.5
15	- 56	Luchuan	18.642	0.84656	2.1059	76.89	14.38	4.37
16	- 32	Cenxi	18.298	0.84708	2.1032	75.17	14.35	5.76

The third type is Lengshuichong drums, distributed along the You, Yu and Xu

rivers, the northern side of those rivers, e.g. Heng, Gui, Pingnan, Teng, Binyang

Table 3

Data for the bronze drums of Lingshan type from Guangxi, China

No.	Sample No.	Unearthed site	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	Cu(%)	Sn(%)	Pb(%)
1	L- 14	Lingshan	18.405	0.85353	2.1076	74.94	11.88	3.10
2	- 104	Nanling	18.398	0.85410	2.1057	68.0	13.0	12.5
3	- 125	Guangxi	18.540	0.84620	2.0989	77.5	7.50	12.0
4	- 33	Guangxi	18.596	0.84572	2.0985	73.59	13.54	3.48
5	L- 02	Lingshan	18.456	0.85011	2.1014	77.26	19.90	0.34
6	- 142	Heng County	18.498	0.84935	2.1037	80.5	7.70	6.20
7	- 132	Guangxi	18.459	0.84935	2.0965	70.56	6.42	16.68
8	L- 09	Lingshan	18.457	0.85112	2.1075	76.17	13.17	1.80
9	- 153	Rong County	18.285	0.85855	2.1097	64.68	8.58	19.76
10	- 335	Heng County	18.520	0.84762	2.0993	75.67	14.86	0.75
11	L- 12	Lingshan	18.450	0.84995	2.0989	84.07	13.70	0.26
12	Q- 33	Qinzhou	18.429	0.85205	2.1026	74.70	12.93	3.39
13	P- 02	Pubei	18.674	0.84189	2.1022	76.00	13.52	2.36
14	P- 06	Pubei	18.364	0.85514	2.1067	71.00	8.70	14.3
15	P- 05	Pubei	18.538	0.84557	2.0969	82.64	15.21	0.44
16	P- 01	Pubei	18.240	0.85957	2.1119	74.92	7.96	1.58
17	H- 370	Hepu	18.379	0.85485	2.1085	81.39	13.57	1.62

Table 4

Data for the bronze drums of Lengshuichong type from Guangxi, China

No.	Sample No.	Unearthed site	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	Cu(%)	Sn(%)	Pb(%)
1	- 01	Guangxi	18.421	0.85982	2.1178	74.99	13.92	0.88
2	- 28	Gui County	18.394	0.86223	2.1224	74.44	8.38	0.69
3	- 29	Guiping	18.324	0.85663	2.1099	75.03	10.57	4.87
4	- 38	Binyang	18.261	0.85862	2.1120	69.2	14.5	16.0
5	- 58	Pingnan	18.274	0.85858	2.1083	62.43	14.94	14.82
6	- 99	Yongning	19.119	0.81833	2.0914	77.35	20.30	0.72
7	- 100	Teng County	18.161	0.86284	2.1123	69.5	9.10	20.6
8	- 110	Jinxiu	18.354	0.85957	2.1146	75.0	3.80	14.5
9	- 117	Guangxi	19.028	0.82499	2.0938	65.0	7.20	25.0
10	- 121	Teng County	18.212	0.86186	2.1154	66.0	11.8	18.9
11	- 124	Pingnan	18.314	0.85810	2.1089	79.98	16.15	2.33
12	- 126	Teng County	18.569	0.85041	2.1098	67.3	8.19	22.0
13	- 136	Heng County	18.571	0.84396	2.0895	67.2	7.33	21.8
14	- 149	Binyang	19.247	0.81679	2.0903	74.03	6.88	14.50
15	- 155	Guangxi	18.521	0.84463	2.0889	73.0	8.70	17.3
16	- 158	Daxin	19.066	0.82335	2.0984	76.92	11.88	0.85
17	- 307	Guangxi	19.278	0.81942	2.0966	71.57	13.35	3.57
18	- 322	Binyang	19.352	0.81728	2.0891	75.92	13.15	3.20
19	G- 03	Gui County	18.327	0.85944	2.1132	73.56	11.74	1.77
20	G- 07	Gui County	18.288	0.85954	2.1123	74.95	19.86	2.69
21	T- 04	Teng County	18.499	0.84712	2.0955	73.22	11.32	4.83
22	H- 05	Heng County	18.377	0.85610	2.1080	69.50	10.50	17.40

etc. Counties. 110 drums of the Lengshuichong type have been excavated in China,

while 80 in Guangxi. The chronology of the three types' drums is listed in Table 1. 16 Beiliu, 17 Lingshan and 22 Lengshuichong drums have been collected for this study (Fig.1). In comparison with the ore sources, 7 Cu- bearing samples, including 3 ancient Cu ingots, 3 ancient Cu ores, 1 ancient Cu slag, and 28 Pb- bearing samples,

Table 5

Data for ore material from the drums' areas and their vicinity of Guangxi, China

Sample No.	Sample species	Unearthed site	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	Cu(%)	Sn(%)	Pb(%)
8631	Cu ore	TSL	18.930	0.83826	2.0902	8.51		4.04
8632	Cu slag	TSL	18.481	0.84908	2.0946	2.37	0.18	0.92
8633	Cu ore	Xishan	18.581	0.85330	2.1091	7.36		1.38
8635	Cu ingot	STV	18.348	0.85552	2.1033	97.84		0.02
8637	Cu ingot	Luexiu	18.404	0.86006	2.1209			
8638	Cu ingot	TSL	18.767	0.83986	2.0927	92.89		0.16
9839	Cu ore	TSL	18.816	0.83904	2.0917			
8658	Sn- P	Bobai					14.97	0.05
8659	Sn- P	Beiliu					63.57	0.69
8657	Sn- P	Guiping					41.50	0.04
87L- 04	Galena	Heng- C	18.352	0.85987	2.1139			77.99
87L- 16	PZO	Chongzho	18.384	0.85833	2.1146			83.26
87L- 20	Galena	Gui- C	17.777	0.87399	2.1280			14.39
87L- 21	Galena	Gui- C	18.564	0.84767	2.1045			79.89
87L- 22	PZO	Gui- C	18.412	0.85675	2.1111			83.79
87L- 23	PZO	Gui- C	18.297	0.85703	2.1091			53.52
87L- 24	PZO	Gui- C	18.684	0.84194	2.0962			15.84
87L- 26	PZO	Guiping	18.862	0.83750	2.0922			76.24
87L- 34	PZO	Wuxuan	18.341	0.85961	2.1142			48.34
87L- 38	PZO	Wuming	18.214	0.86136	2.1114			73.40
87L- 40	PZO	Mashan	18.147	0.86517	2.1191			84.92
87L- 41	PZO	Shanglin	18.258	0.86191	2.1162			71.92
87L- 43	PZO	Daxin	18.631	0.84351	2.0880			9.74
8651	PZO	Heng- C	18.352	0.86173	2.1235			13.24
87L- 07	PZO	Pubei	18.604	0.84576	2.0992			2.24
87L- 08	PZO	Pubei	18.666	0.84403	2.1020			29.84
87L- 12	PZO	Yongning	18.388	0.85676	2.1109			62.30
87L- 15	PZO	Fushi	18.396	0.85833	2.1123			85.26
87L- 30	PZO	Teng- C	18.629	0.84228	2.0995			50.88
87L- 32	Galena	Cenxi	18.609	0.84480	2.1047			69.23
8636	Pb ingot	STV	18.258	0.85971	2.1227			
8641	PZO	Bailian	18.697	0.84543	2.1110			8.01
8643	PZO	Cenxi	18.318	0.86512	2.1287			83.15
8644	PZO	Cenxi	18.820	0.83200	2.0867			65.61
8645	PZO	Cenxi	18.704	0.84281	2.1044			81.64
8647	PZO	Luchuan	18.274	0.86367	2.1170			6.64
8649	PZO	Bobai	18.374	0.86252	2.1227			12.29
8664	BP	TSL	18.715	0.83694	2.0744	0.31		4.04

Note: PZO: Pb- Zn ore BP: Blast pipe Sn- P: Sn placer Cu ore: ancient Cu ore Cu slag: ancient Cu slag Cu ingot: ancient Cu ingot Pb ingot: ancient Pb ingot TSL: Tongshiling, Beiliu STV: Shitou Village, Rong County Heng- C: Heng County Gui- C: Gui County Teng- C: Teng County

which are 22 Pb- Zn ores, 4 galena, 1 ancient Pb ingot and 1 blast pipe, and 3 Sn plases have also been used for this study (Fig.1). The experimental results are shown in Tables 2—5. A part of this study has been published in paper of " Tests on Ancient Bronze Drums of the Beiliu Type by Lead Isotopes" [13]. However, for the sake of reviewing the three types' drums, excavated in Guangxi, the early results will be summarized in this paper.

Ⅱ. RESULTS AND DISCUSSIONS

1. The Beiliu type drums

1) The chemical compositions of 16 drums show that one drum has each of both the Sn and Pb contents less than 2%, which means the drum was made of rather pure copper, i.e. so called the red copper[13]. 8 drums contain Sn larger than 2%, while Pb less than 2%. That are Cu- Sn bronze. The other of 7 drums were made of Sn and Pb higher than 2%, respectively, which belong to Cu- Sn- Pb bronze[14]. The variation of Cu, Sn and Pb contents in the drums is an important sign in the technological envolution of ancient manufacture. As general understandably thinking, the drums in the early stage were made by rather pure copper, then that in the middle and late stages by Cu- Sn and Cu- Sn- Pb bronze as people getting more and more knowledge on alloys. Therefore, the 16 drums can roughly represent the Beiliu type drums made in the whold period from the early stage of Western Han Dynasty to the late stage of Tang Dynasty.

2) Fig.2 shows the distribution of the lead isotopic ratios of the Beiliu type drums.

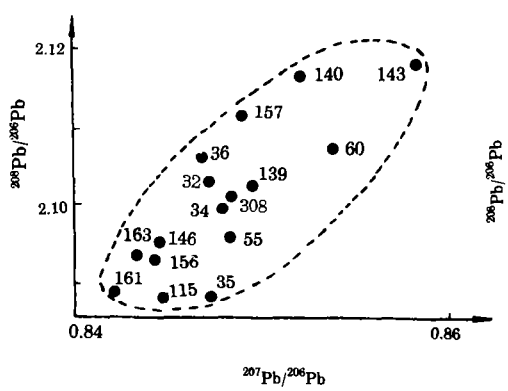

Fig.2 The lead isotopic distribution of Beiliu type's drums

The ratios of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ are corresponding to 0.8420—0.8582 and 2.087—2.117, respectively (Table 2)

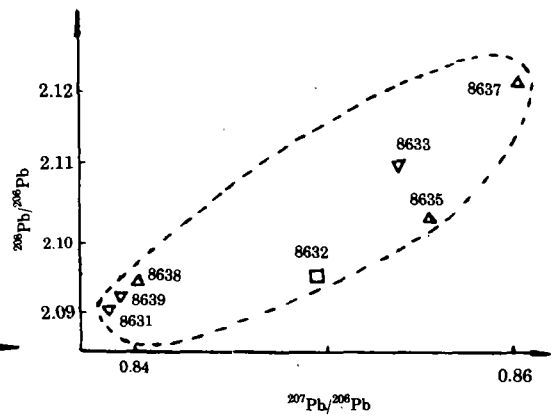

Fig.3 The lead isotopic distribution of ancient Cu ingot (△), ancient Cu ore (▽) and ancient Cu slag (□)

The ratios of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ are dropped in the ranges of 0.8420—0.8582, and

2.087—2.117, respectively. All the ratios vary only in 1%. In addition, the ratios of 5 drums excavated from Beiliu County is merely varied in less than 0.5%. It can be inferred that the ore sources were comparatively restricted in a certain area and its vicinity.

3) Fig.3 shows that the lead isotopic distribution of ancient Cu ores, ancient Cu ingots and ancient Cu slag from Tongshiling of Beiliu County, Rong County, and

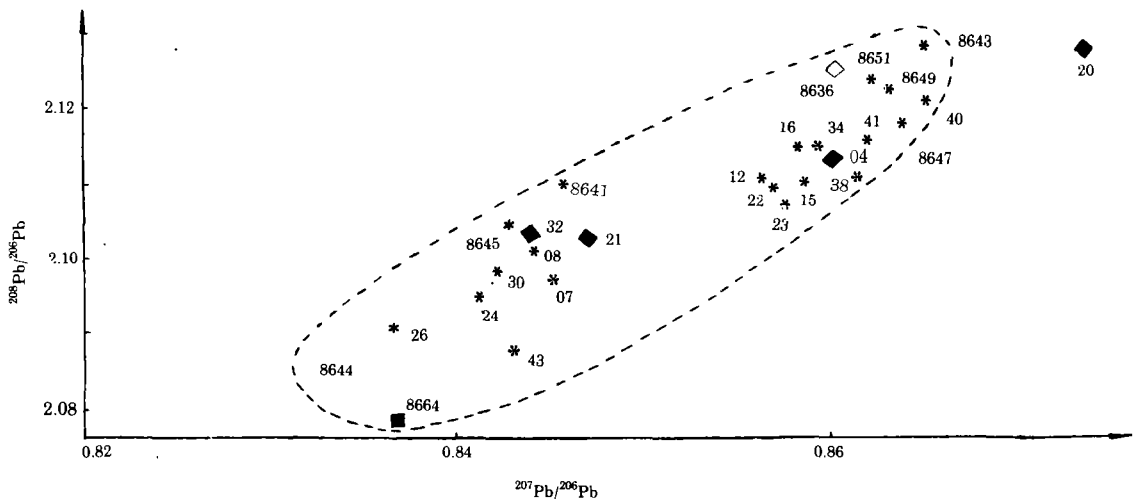

Fig.4 The lead isotopic distribution of Pb—Zn ores(*), galena (◆) ancient Pb ingot (◇) and ancient blast pipe (■)

Guiping areas. The lead ratios of the copper ingot (8638) from Tongshiling is close to that of two Cu ore samples (8631, 8639) unearthed in the same place, which implicates the casting material for the Cu ingot is indeed from the local Cu ore deposite. The same case has happened in the samples of the Cu ingot (8635) and the Cu ore (8633) from Rong County. However, it can be seen that the data of the Cu ingot (8637) from Guiping are different from that of two groups as mentioned above. It is obvious that the zoning of Cu ore material can be revealed in certain regularity by lead isotopes.

4) It is interesting to see that the distributed field of the lead isotopic ratios for the drums is almost covered by that for the Cu ore material (Fig.5). The lead data of the drums are concentrated in the

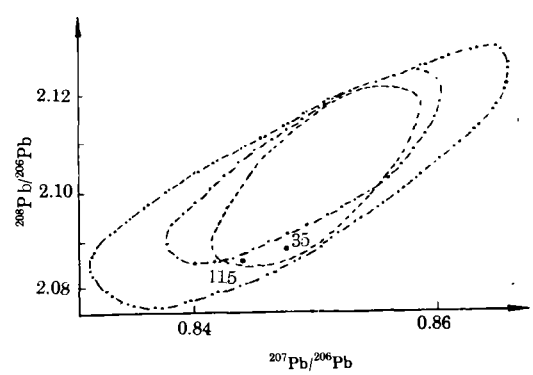

Fig.5 In comparison of the distribution of Beiliu type's drums (— — —) with that of the Cu— (— · — · —) and Pb—bearing samples (— · · — · · —)

distribution of that of the ore material from Tongshiling of Beiliu County and Xishan and Shitou Village of Rong County. Therefore, we can further infer that the Cu ore material of Beiliu drums came from the above- mentioned areas.

5) However, it should be pointed out that 7 of the 16 drums belong to the Cu- Sn- Pb alloy. It is commonly believed[14] that the bronzes can be cast by the external Pb ore material if it contains more than 2% of Pb. But, where did the Pb bearing ores come from? For the purpose of clarifying the question, we have collected 28 Pb- bearing samples shown in the sampling sites and plotted their Pb isotopic ratios as indicated in Fig.4. The lead ratios vary up to 4%, which is larger than that of the drums. It is noticed that two points corresponding to Drum—35 and Drum—115 with lead contents of 5.5% and 21.5% respectively, do not fall in the field of Cu- bearing ores, but in that of Pb bearing ores (Fig.5). Thus, it is believable that the Pb material for casting the drums should have come from the sampling areas. We would like to point out that one part of the Pb- bearing ores were collected in 1986 (see Samples' Nos. in Table 5) and located at Rong, Cenxi, Luchuan areas. The lead isotopic distribution of those samples can still keep the same shape, even through more data from the northern side of You, Yu and Xun rivers (Fig.1) were created in 1987 (Table 5).

2. The Lingshan type drums

We have collected 17 drums, 7 of which contain Sn>2%, and Pb<2%, while 10

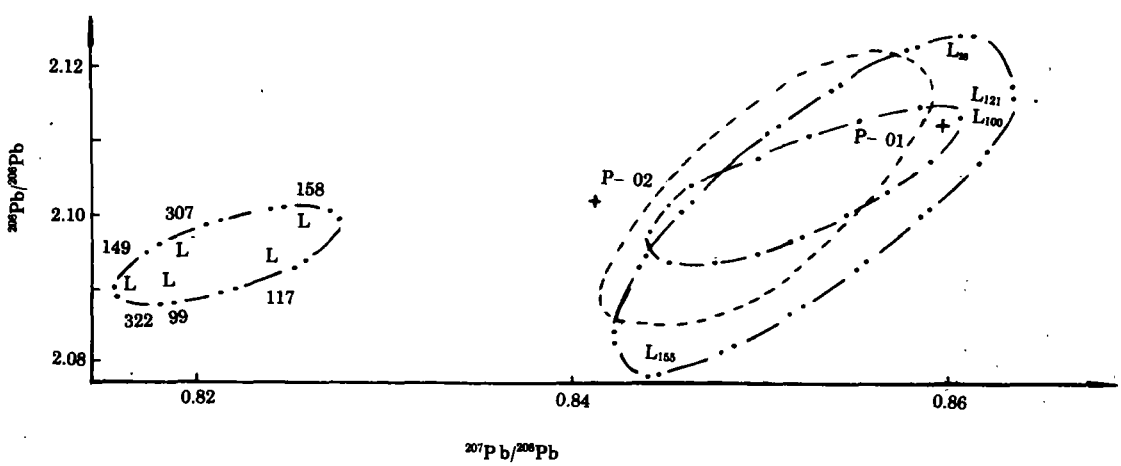

Fig.6 In comparison of the distribution of Beiliu type's drums (— — — —) with that of Lingshan (— · — · — · —) and Lengshuichong type's drums (— · · — · · — · · —)

contain Sn>2% and Pb>2%. The ranges of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ are 0.8456—0.8596, and 2.096— 2.112, respectively. Their variation of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ is all corresponding to ≤1%.

Comparing the distribution of Lingshan drums with that of Beiliu ones (Fig.6), we

find that 15 of 17 the drums are dropped in the distributed field of Beiliu drums. The other two (P- 01, P- 02) were unearthed from Pubei County, where the Beiliu type drum has not been found so far. Both type drums have almost the same of the excavated location (Fig.1) and the most overlapped distribution of the lead ratios, from which can be inferred that they have the similar ore sources.

For further investigation as shown in Fig.7, the distributed field of the lead isotopic ratios for Lingshan type drums is almost covered by that of the Cu- bearing ore material, and completely covered by that of Pb- bearing material. In addition, it is reasonable to think that Sample No. P- 02 contains higher than 21% Pb, which cannot be dropped in the field of Cu- bearing material, but in that of Pb- bearing ores (Fig.7). In comparison of the lead ratios of Lingshan drums with that of raw material, it can be found that their Cu ores could come from Rong County and Beiliu areas, while the Pb ores from Guiping, Cenxi, Pubei, Heng, Gui Counties, where the drums were excavated, or nearby.

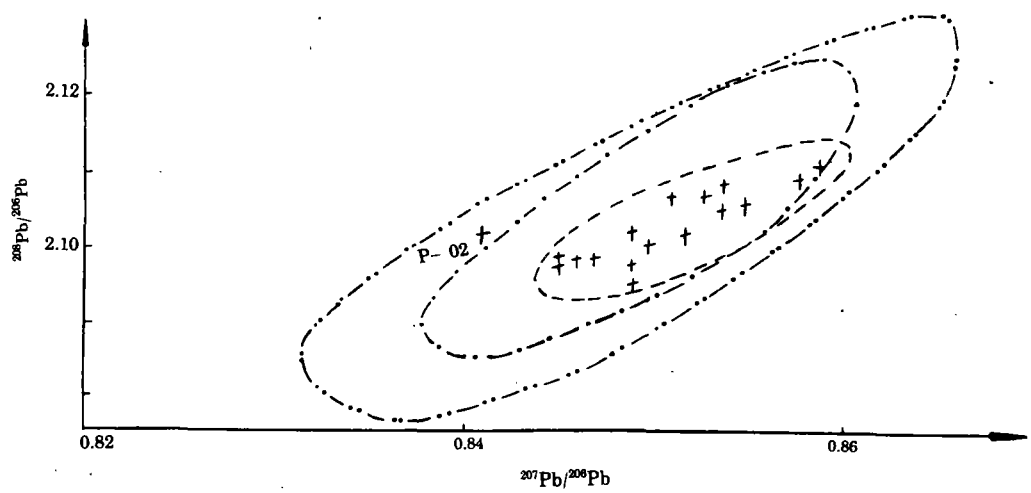

Fig.7 In comparison of the distribution of Lingshan type's drums (— — — — —) with that of the Cu- (— · — · — · —) and Pb—bearing samples (— · · — · · —)

3. The Lengshuichong type drums

There are 22 drums for our study. 5 drums of them contain higher than 2% Sn, while less than 2% Pb. The other 17 do higher than 2% of Sn and Pb, respectively. The lead ratios of $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ are in the ranges of 0.8168—0.8628 and 2.089—2.122, respectively.

The variation of $^{208}Pb/^{206}Pb$ is less than 2%, while that of $^{207}Pb/^{206}Pb$ equals to 3.9%, which is obviously higher than that of the two type drums mentioned above. Fig.6 shows that Lengshuichong drums have their own distribution. One field was distributed by 16 drums, 12 of which were dropped in the distribution of Beiliu and

Lingshan drums. Another containing 6 drums is distributed in an independant field. It means that Lengshuichong drums could have certain ore sources, a part of which are the same as that of the first two type drums, while the other are obviously different from the sites as discussed above. In comparison of the lead ratios of Lengshuichong drums with that of the ore material (Fig.8), the samples (Drum– 100, – 121, – 155) are out of the distribution of Cu– bearing material, because they contain the Pb concentration of 18.9%, 20.6% and 17.3%, respectively. Such high Pb composition implicates that the external Pb– bearing ores or ingots were added, then, cast into the bronze drums with Cu and Sn raw material. Fortunately, it can be seen from Fig.8

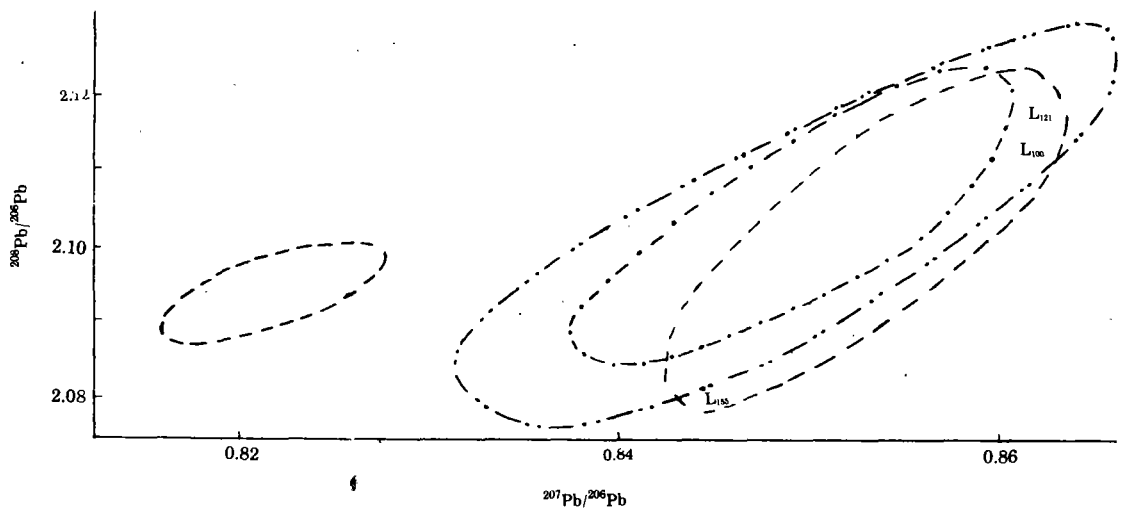

Fig.8 In comparison of the distribution of Lengshuichong type's drums (– – – –) with that of Cu– (– · – · – · –) and Pb–bearing samples (– · · – · · –)

that two points of Drum– 121 and – 100 are truly dropped in the Pb raw material field, while that of Drum– 155 is still out. The latter drum was only known from Guangxi Province,therefore, its ore material could come from another area. Six of Lengshuichong drums are occupied in a independent field and their ratios of the lead isotopes are ranged in 19.028— 19.352, 15.645— 15.800, and 39.848— 40.437 in correspondance to $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$, respectively. Based on the Principle of Isotope Geologe[15], the six samples contain so called abnormal Pb ores. Such high ratios have not been found in Cu– and Pb– bearing raw material from Guangxi and its neighbouring Provinces e.g. Yunnan, Guizhou, Guangdong, where the ancient drums have also been excavated. There are some possibilities for the interpretation of the phenomenon: one is that some Cu– and Pb– ore deposits were exhausted in the ancient time, or the old mining was destroied and has not been excavated so far. The other is that the ore material or those drums could have come

from distant places even from foreign countries because the Lengshuichong type drums have also been found in South- East Asia countries. If the latter is the case, it is very interesting for the archaeologists to reveal the social activity, e.g. trade, cultural exchange, etc. between China and those countries existed as early as 25—220 A.D.

Ⅲ. CONCLUSIONS

1. The Beiliu and Lingshan type drums were excavated in large mixing areas and developed in the same period of the ancient time[19], which correspond to their lead ratios also overlapped in the mixing isotopic fields. Based on the Pb isotope studies of the drums in comparison with that of the ore material, it should be inferred that the Cu- and Pb- bearing ores for making the drums were taken from Tongshiling of Beiliu County, Xishan Village of Rong County and their vicinity.

2. A part of Lengshuichong drums with some of Beiliu and Lingshan drums have the mixing distribution of the Pb isotopes, that is consistant with three types'drums unearthed in the mixing sites along the You and Yu rivers and the same ore sources as mentioned above. However, the others have independent ones, which have not been found in the local Province and its vicinity so far. Where the raw material come from awaits further study.

3. The archaeologists discovered in 1966 in Tongshiling of Beiliu County was a big Han Dynasty ruin for smelting Cu ore[16]. The neighbouring areas of Tongshiling are Xishan and Shitou Village of Rong County, and Luexiu Village of Guiping County, (Fig.1) where ancient Cu ores, Cu and Pb ingots and Cu slags were also unearthed. There were the smelting Cu ruins too. 4 places of Tongshiling, Xishan, Shitou Village and Luexiu Village were really connected as a minerogenitic region, located in Dairong Mountains. The other ruins for smelting Cu ore since Han through Wei Dynasty was discovered in Cenxi County, situated at the east side of Beiliu and Rong County areas (Fig.1). In addition, we have collected three Sn places from Beiliu, Guiping, and Bobai areas and analysed their Sn contents, ranged in 15—64% (Table 5). It is obvious that a large amount of Cu, Sn and Pb material for making the drums could easily be taken from Tongshiling and its vicinity. Moreover, the lead data have strongly proved that the Cu ingot (8635), excavated from Shitou Village of Rong County (Table 5), was made of local Cu ore material (see Ⅰ, (1), c), while one Pb ingot (8636) found together with the Cu ingot (8635), has the different ratios of the lead isotopes from that of the Cu ingot, even from that of the Pb- Zn ore (8641), unearthed at the same county. However, the variation of the Pb isotopic ratios between the Pb ingot (8636) and the Pb- Zn ore (8651) are in a small range of 0.17% for $^{207}Pb/^{206}Pb$ and 0.03% for $^{208}Pb/^{206}Pb$. It means that it was possible for the Pb raw material to have been

transported there from outside areas, e.g. Heng County (Sample No.8651) to Tongshiling and Shitou region for making the drums. It should also be pointed out that the 47 Beiliu type drums (about one third of the total amount of Beiliu drums known so far) were unearthed only in one county- Beiliu. Therefore, based on the description as mentioned above, it can be concluded that Tongshiling and its vicinity were not only the areas for smelting the copper ores, but possibly also for casting the bronze drums, i.e. The Beiliu, Lingshan and Lengshuichong type in the ancient time.

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REFERENCES

[1] R.H.Brill and J.M.Wampler, *Am. J. Archaeol.*, **71** (1967), 63.

[2] K.Yamasaki et al., *J. Chem. Soc. Japan*, **8** (1978), 1112.

[3] H.Mabuchi and Y.Hirao, *Museum*, **370** (1982), 4.

[4]H.Mabuchi et al., *Archeometry*, **27** (1985), 131.

[5] R.H.Brill and W.R.Shields, Methods of chemical and metallurgical investigation of ancient coinage, Royal Numismatics Society, New York, 1972, p.279—303.

[6] I.L.Barnes et al., The proceedings of international symposium of glass discussion, The Architectural Press, Beijing, 1986, p.34—46.

[7] K.Yamasaki et al., The proceedings of internatinal symposium of glass discussion, The Architectural Press, Beijing, 1986, p.47—52.

[8] R.H.Brill et al., *Museum of Fine Arts*, Boston, 1970, 77—83.

[9] H.Craig and V.Craig, *Science*, **176** (1972), 401—403.

[10] Z.C.Peng et al., *Kaogu (Archaeology, in Chinese)*, **11** (1985), 1032—1037.

[11] Z.C.Peng et al., Yu State Cemeteries in Baoji, The Cultural Relics Publishing House, Beijing, 1988, 639—645.

[12] I.L.Barnes et al., *Analytical Chemistry*, **45** (1978), 1881—1884.

[13] Z.C.Peng et al., *Kexue Tongbao (Science Bulletin)*, **33** (1988), 1028—1033.

[14] G.Wen, *The Geological Review*, **26** (1980), 331—340.

[15] Z.C.Peng et al., *Chemical Geology*, **59** (1986), 3—33.

[16] The Cultural Relic Team of Guangxi, *Kaogu (Archaeology)*, **5** (1985), 404—410

[17] S.A.Yao et al., *Kaogu (Archaeology, in Chinese)*, **6** (1988), 556—561.

[18] J.S.He, A selection of ancient bronze drums (Ⅱ), The Cultural Relics Publishing House, Beijing, 1986, p.39—46.

[19] T.Y.Jiang, A selection of ancient bronze drums (Ⅰ), The Cultural Relics Publishing House, Beijing, 1982, p.139—151.