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A glimpse into the monetary supply network of the Tang empire in the seventh century CE: archaeometallurgical study of Kaiyuan Tongbao coins from Lafu Queke cemetery, Xinjiang, Northwest China

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Abstract

The supply of coins and their metal materials is important for state governance. Many details about the monetary supply network in ancient China still need to be verified. In this paper, 15 early Tang dynasty Kaiyuan Tongbao 開元通寶 coins excavated from the Lafu Queke 拉甫却克 cemetery, Hami 哈密 city, were studied by combining scientific analyses (PXRF and MC-ICP-MS etc.) with the archaeological context and historical texts. The results show that all of these coins are made of Cu-Sn–Pb ternary alloy. The lead isotopes match with the isotopic signatures of some southwest China lead mines consistent with historical records, 14 coins are located in the range of Southern China geochemical province, and the lead of 5 coins could be considered as highly radiogenic lead (HRL). Combining these results with the archaeological context and historical texts, it can be inferred that the coins minted in southwest China were made from locally exploited raw metal, and supplied to the northwest borderland of the Tang dynasty in the seventh century CE.

Keywords: Coins, China, Tang dynasty, Lead isotope

Introduction

The supply of coins and their metal materials is important for state governance, since the minting of coins is related to central authority in almost all societies, and the usage of coins generally involves all social strata and permeates throughout every corner of the territory [1]. For example, in Ancient Rome, in order to establish a monetary supply network that would sustain imperial power for many centuries, the Imperator and Senate needed sophisticated social organization to manage the supply of metal materials, minting, as well as the deployment of coins to different regions, owing to the uneven distribution of mineral resources and production capacity throughout the vast territory [2–7].

China has a long history of minting coins, going back more than 2600 years [8], and the monetary supply network changed over time. The issue of Banliang 半两 coins in the Qin dynasty (221 ~ 207 BCE) symbolized the establishment of a centralized monetary system [9], and a prototype of an imperial monetary supply network seemed to form at this time, as inferred from the relatively united provenance of mintage raw material [10]. Nevertheless, from the end of the Han dynasty (202 BCE ~ 220 CE), the empire split, initially into three kingdoms, and subsequently divided further, and the accompanying monetary chaos continued for more than four centuries. Political reunification occurred in the Sui

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(581–618), and became more secure in the Tang dynasty (618–907). The issue of Kaiyuan Tongbao 开元通宝 coins heralded a new system of coinage [11, 12].

According to the *Monograph on Food and Money* (*Shi Huo Zhi* 食货志) in the *New Tang History* (*Xin Tang Shu* 新唐书) and the *Institutional History of Tang* (*Tang Hui Yao* 唐会要), during the 4th and 5th years of the Wude 武德 reign (621, 622), mint offices (*qianjian* 钱监) were established in Luozhou 洛州, Bingzhou 并州, Youzhou 幽州, Yizhou 益州 and Guizhou 桂州 prefectures (Fig. 1b). From these historical texts, although it is clear that the intention for the early Tang monetary supply network was have coins minted in different places under the management of mint offices appointed by the central government, there are still many details to be verified, especially the distribution of coins produced by the mint offices, and which mines supplied the raw metals for making the coins.

In regard of the problems above, this study selects 15 Kaiyuan Tongbao 開元通寶 coins excavated from the Lafu Queke cemetery in Hami city, Xinjiang Uygur Autonomous Region, northwest China as the research object. A series of scientific analyses are presented, with discussions in the context of archaeological and historical understanding, which allow a glimpse into the monetary supply network of the Tang empire in the seventh century CE, and provide a new insight on the issues of metal and monetary supply, as well as borderland governance in ancient China.

Given the limited sample size and archaeological site, the findings of this study are still preliminary, and further studies are needed to add richer and more accurate understanding to these issues.

Archaeological context and material

The Lafu Queke cemetery is located 60 km northwest of the Lafu Queke ancient city site, which is considered to be the remains of Nazhi 纳职 county, Yizhou 伊州 prefecture in the Tang dynasty, recorded in the *Yuanhe Atlas of Prefectures and Counties* (Yuanhe Junxian Tuzhi 元和郡县图志) (Fig. 1). In 2019 and 2020, this cemetery was excavated by the Xinjiang Institute of Archaeology and Cultural Relics, and a total of 102 tombs were uncovered, including 21 tombs with a sloping path (TSP), 20 catacombs with a vertical shaft (CVS), 58 burials on the ground (BG) and 3 tombs of children [13]. More than 200 objects were found, such as pottery, metal artifacts and woodware etc. A total of 44 coins were excavated from 20 tombs, including 36 Kaiyuan Tongbao, 1 Wuzhu 五铢 and 7 Sasanian silver coins.

Judged by archaeologists, the TSP were consistent with the burial custom of Han Chinese, dating roughly in the early and middle Tang dynasty. The CVS were most likely Sogdian 粟特人 burials, dating from the Northern and Southern Dynasties (420～589) to the middle Tang dynasty. The BG were probably associated with Uyghur 回鹘人 burials dating from the late Tang to the Northern Song dynasty (960～1127). The occupants of most of the tombs were commoners, however, two of TSP—that is, M3 and M9—were brick-chambered tombs and considered to belong to high-ranking individuals [13]. Unfortunately, very few objects were found in these tombs owing to serious destruction.

The three oases of Hami, Turfan and Jimsa, in the eastern part of Xinjiang, where Chinese influence was most evident, were incorporated into the Chinese prefecture/county administration, and named as Yizhou 伊州, Xizhou 西州 and Tingzhou 庭州 prefectures, respectively (Fig. 1), acting as an example of the internalized governance of the borderlands in the early Tang dynasty [14, 15]. In the 14th year of the Zhenguan 贞观 reign (640), the Anxi 安西 commandery (Duhu Fu 都护府) was established in Xizhou prefecture, and a complete military and political system was established in these three prefectures according to the laws and decrees of the Tang empire [16]. Thus, the classic term "Western Regions" (Xiyu 西域) changed semantically and the border of the Tang empire moved westward [17]. The discovery of many administrative documents in the Turfan district has provided concrete evidence of Tang dynasty rule in these three prefectures.

Except for the extremely rare Gaochang Jili 高昌吉利 coins [18], scarcely any of the metallic coins used in these three prefectures were locally minted. Meanwhile, local minting of coins took place further west in the kingdom of Qiuci (present-day Kucha) [19]. Thus, discussing the issue of monetary supply could reflect the vicissitude of regional political and economic situation [20]. Based on contemporary documents excavated from sites in Turfan, silk and Sasanian silver coins were also used as currency in this region during the sixth and the early seventh centuries CE. Bronze Chinese coins began to appear in the reign of Emperor Gaozong 高宗 (649～683), but didn't completely replace the silver coins until the beginning of the eighth century CE [20–25]. In fact, since Aurel Stein's expeditions in the early twentieth century, a large number of bronze coins issued by Tang government have been found in Xinjiang, many of which were Kaiyuan Tongbao [26].

(See figure on next page.)
Fig. 1 Maps showing geographical names in modern times (**a**) and the Tang dynasty (**b**)

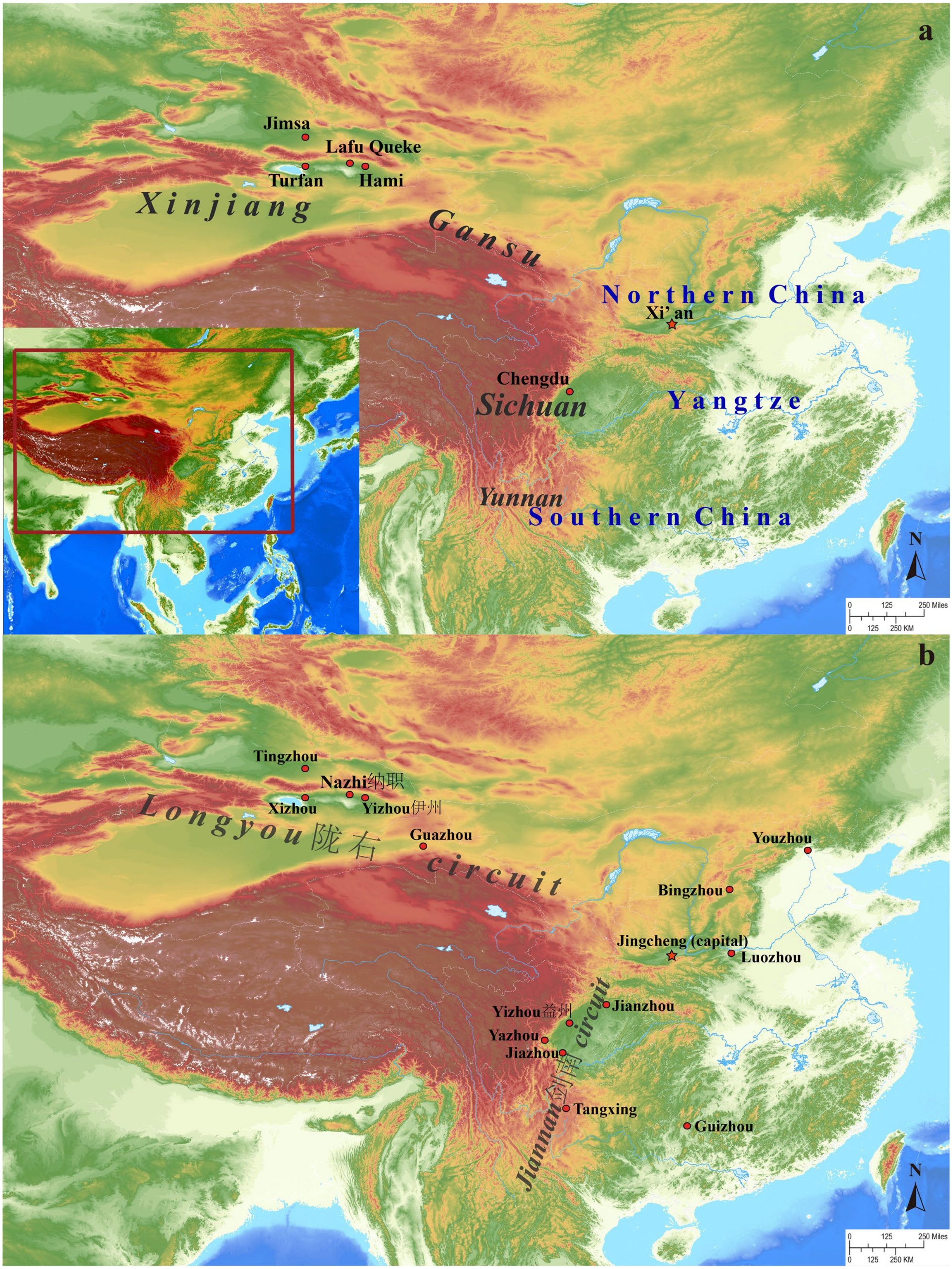

Fig. 1 (See legend on previous page.)

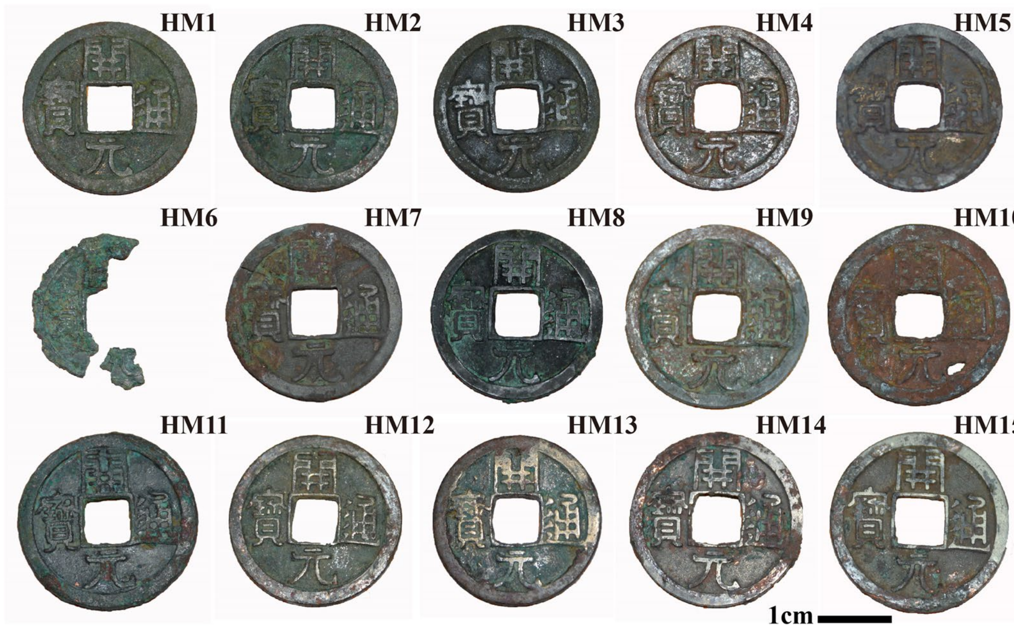

Fig. 2 15 Kaiyuan Tongbao coins recovered from Lafu Queke

Table 1 Information concerning the Kaiyuan Tongbao coins from Lafu Queke (blank space represents not measured), TSP: tombs with a sloping path; BG: burials on the ground; CVS: catacombs with a vertical shaft

Lab No	Burial No	Tomb	Structure	Archaeological context	OD (cm)	ID (cm)	Wt (g)
HM1	2019HLM3:2	M3	TSP	150 cm to the west wall	2.5	0.7	4.67
HM2	2019HLM9:1	M9	TSP	On the sloping path	2.4	0.65	4.31
HM3	2019HLM11:5	M11	BG	Southwest corner	2.4	0.6	3.66
HM4	2019HLM12:2	M12	BG	Out of the east side	2.4	0.7	3.08
HM5	2019HLM24:2	M24	CVS	Near the mouth of female	2.4	0.7	3.97
HM6	2019HLM34:3	M34	TSP	Near the right arm of male			
HM7	2019HLM34:4	M34	TSP	Near the legs of female	2.5	0.7	3.73
HM8	2019HLM37:1	M37	CVS	In the mouth of male	2.4	0.7	3.85
HM9	2019HLM42:3	M42	TSP	In the center of the tomb	2.5	0.7	3.9
HM10	2019HLM42:5	M42	TSP	Near the hand of male	2.5	0.7	3.55
HM11	2019HLM42:8	M42	TSP	Northeast corner	2.5	0.65	4.33
HM12	2019HLM44:2	M44	TSP	On the top of head of female	2.4	0.7	3.24
HM13	2019HLM53:1	M53	CVS	In the bottom of coffin	2.3	0.65	3.67
HM14	2019HLM53:2	M53	CVS	In the bottom of coffin	2.4	0.7	3.45
HM15	2019HLM57:4	M57	CVS	Held in the left hand of female	2.5	0.7	4.22

The 15 Kaiyuan Tongbao coins in this study come from 11 tombs in the Lafu Queke cemetery (Fig. 2), with most of those tombs dating around the early Tang dynasty, detailed information is given in Table 1. According to the *Old Tang History* (*Jiu Tang Shu* 旧唐书), *New Tang History* and *Encyclopaedic History of Institutions* (*Tong Dian* 通典), Kaiyuan Tongbao coins were first issued by Emperor Gaozu in the 4th year of the Wude reign (621), and continued to be minted throughout almost the whole Tang dynasty. The Kaiyuan tongbao had a profound impact on Chinese monetary history, and marked a new beginning as the inscription suggests (Kaiyuan means "start anew"). It continued the tradition of using a round coin with a raised rim and a square hole in the center, but stopped using a weight reference as the inscription, and initiated a four-character inscription, ending in *Tongbao*

通寶 ('circulating treasure') or *Yuanbao* 元寶 ('first/original treasure'), which remained the standard design of Chinese coinage throughout the subsequent thirteen centuries [27]. In time, it became usual practice to use the current era name for the first two characters in the inscription.

Great attention was paid to the calligraphy on the Kaiyuan Tongbao coins, which was initially provided by the great calligrapher Ouyang Xun 欧阳询 (ca. 557 ~ ca. 641). Kaiyuan "new start" also referred to the calligraphy, and marked the beginning of a more standard and legible script than on previous inscriptions in seal script [8, 28]. In the western world, the texts, images and material of coins embodied connotations of value, trust and identity [1]. The emergence of Kaiyuan Tongbao coins was just an embodiment of this rule in ancient China.

Although the inscription Kaiyuan Tongbao did not indicate a specific era, some systematic typological studies show that it is possible to distinguish among coins produced in the early, middle and late Tang dynasty [29–31]. Based on coins found in tombs with dated epitaphs [29–31], it has been noted that the Kaiyuan Tongbao coins of the early Tang dynasty were generally of a higher quality than later Kaiyuan Tongbao coins, with sharper inscriptions, full size (2.4 cm) and weight (4 g), and without markings (e.g. a crescent) on the reverse. The arrangement of the inscription also has certain features: the jing 井 component of kai 開 does not touch the hole (Fig. 3, top). The top stroke of yuan元 was short (Fig. 3, bottom). The radical 辶to the left of tong 通 is not continuous (Fig. 3, left). The two strokes in the middle of bei 貝 in bao 寶 do not touch the verticals (Fig. 3, the right). According to these characters, the date of the 15 Kaiyuan Tongbao coins in this study were attributed to the early Tang dynasty, or to be more exact, no later than the reign of Emperor Gaozong 高宗 (649 ~ 683), and confirmed by Prof. Dr. Yang Jun, a senior numismatist from the China Numismatic Museum.

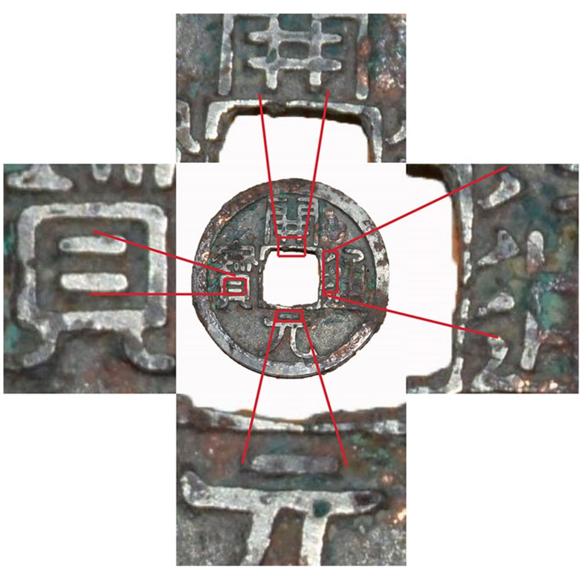

Fig. 3 Typological characteristics of the early Tang Kaiyuan Tongbao coin

Analytical methods

Preprocessing and sampling

Given the small size of the coins, destructive sampling analysis would inevitably cause obvious changes to the appearance. Thus, a non-destructive technique was preferred. Provided that a sufficiently large metallic surface (about 1 ~ 3 mm) can be exposed to the light spot of the instrument, it is possible to obtain sound data on the nature and approximate concentrations of the main constituents in copper-based alloys such as tin and lead [32]. Therefore, areas with as little rust as possible on the surface of the coins were selected to be analyzed.

For lead isotope analysis, a few superficial corrosion powders are enough to represent the lead isotopic signature of bronze artifacts, to which lead has been intentionally added [33, 34]. Moreover, some simulation experiments showed that the lead isotopic composition of corrosion rinds (within experimental error) is similar to that of the metallic matrix of bronze. Thus, in order to protect the integrity of the artifacts to the greatest extent, corrosion rinds can be used to investigate the provenance of ancient bronzes [35, 36]. In this study, the corrosion rinds were carefully removed from the surface of the coins using a scalpel, and the dust was exfoliated by an ultrasonic shock.

Component analyses

Component analyses were performed by a handheld XRF instrument (Niton XL3t 950He from Thermo Fisher Scientific, Billerica, USA). The main filter was operated at 50 kV with a current of 10μA. The alloy mode was selected and elemental data were obtained with an acquisition time of 60 s. The detection limits were 70 ppm for Sn and 35 ppm for Pb. While testing, the 32LB10E of the Copper CHARM Set standard sample was used for quality control [37]. The errors in the main compositions were essentially no more than 5%. The results are suitable for semi-quantitative comparisons due to the inevitable chemical heterogeneity in the ancient metallurgical products [38].

Lead isotope analyses

The details of sample preparation are described elsewhere [39]. The lead contents of the sample solutions were measured by inductively coupled plasma-atomic emission spectrometry (ICP–AES, Leeman Labs Prodigy, USA), with the working conditions as follows: RF power 1.1 kW, argon plasma gas flow rate 20 L/min, and nebulizer gas at 20 MPa. After that, the solutions were diluted to the tolerance limit of the instrument (about 1 mg/L), and thallium (Tl) standard solution-SRM997 was added. Lead isotope analyses were performed by Multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS, VG Elemental Axiom, Thermo Fisher Scientific Inc., USA), at School of Earth and Space Sciences, Peking University. The results of repeated runs for the SRM981 determination and the published values from Cattin et al. [40] are listed in Table 2.

Results

Chemical compositions

Chemical compositions in this study are shown in Table 3. The content ranges from 44.8% to 71.1%, 14.1% to 29.6%, and 5.5% to 26.2% for copper, tin and lead respectively. Previous scholars have carried out systematic works on the alloy composition of ancient Chinese coins [41–43], which showed that the content of Kaiyuan Tongbao coins in the Tang dynasty generally ranged from 52 to 94%, 0.2% to 29.0%, and 1.4% to 33.2% for copper, tin and lead respectively (Additional file 1: Table S1). The chemical compositions of our samples are similar to the previous studies, and the lower copper contents and higher tin contents could be attributed to the effect of corrosion enrichment on the surface [32].

Table 2 The results of three runs for the SRM981 determination and published values from Cattin et al. [40]

ICP-MS	SRM981		
Number	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
1	16.947	15.499	36.724
2	16.945	15.498	36.721
3	16.941	15.494	36.719
Recommended values	16.942	15.496	36.720

Lead isotope

Lead isotope ratios of the 15 coins range from 18.190 to 19.313 for $^{206}Pb/^{204}Pb$, 15.661 to 15.817 for $^{207}Pb/^{204}Pb$ and 38.631 to 40.442 for $^{208}Pb/^{204}Pb$ (Table 3). Different perspectives about the introduction of lead have been mentioned by western scholars [44–46], while, the conventional threshold is considered to be 2% in most published studies of ancient Chinese metallic artifacts [47]. In this regard, the overall lead contents of the coins in this study are not lower than 10%, except for HM5 (5.5%), suggesting that the lead was added on purpose and the lead isotopes may be able to indicate the source of lead ores.

Discussion

Provenance of raw material

To date, there are in total 16 published lead isotope ratios of Tang dynasty bronze coins, including 13 Kaiyuan Tongbao coins collected from Japan [48, 49], and 3 coins unearthed from the Chengdu Plain [50], however, it is unfortunate that none of them had more specific information of date (i.e., early, middle or late Tang dynasty). In this context, the value of these 15 early Tang Kaiyuan

Table 3 The chemical compositions and lead isotope ratios of the Kaiyuan Tongbao coins from Lafu Queke

Lab No	Cu (wt.%)	Sn (wt.%)	Pb (wt.%)	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
HM1	59.5	14.3	20.5	18.598	15.787	39.190
HM2	48.9	14.1	22.9	18.427	15.817	38.910
HM3	61.2	14.3	20.0	18.304	15.661	38.672
HM4	63.8	14.5	20.3	18.428	15.807	38.903
HM5	71.1	21.2	5.5	18.929	15.779	39.709
HM6	45.4	24.8	17.9	19.238	15.771	40.238
HM7	58.5	24.1	16.0	18.526	15.760	38.975
HM8	44.8	29.6	22.9	19.313	15.779	40.442
HM9	54.7	18.3	26.2	18.440	15.803	38.984
HM10	70.4	14.7	10.3	18.518	15.777	38.976
HM11	62.6	19.5	15.2	19.155	15.784	40.137
HM12	67.2	14.4	10.0	18.911	15.770	39.688
HM13	64.9	15.9	12.3	18.190	15.690	38.631
HM14	66.6	14.1	10.6	19.213	15.778	40.270
HM15	66.2	17.5	15.2	19.101	15.772	40.048

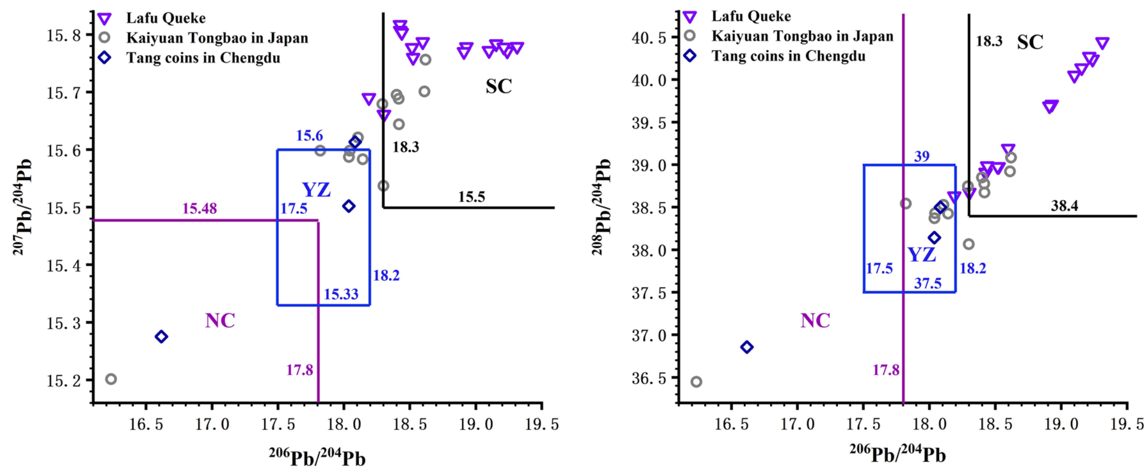

Fig. 4 Lead isotope ratios of the Lafu Queke samples and other Tang coins

Tongbao coins from the Lafu Queke cemetery should not be overlooked. The data of this study and the previous studies (Additional file 1: Table S2) are plotted in Fig. 4. Based on the theory of geochemical provinces in China [51, 52], it can be seen that the whole data set is distributed in three different ranges, belonging to Northern China, Yangtze and Southern China geochemical provinces respectively. More impressive is that 14 data of this study are located in the range of Southern China province, and five of them, namely HM 6, 8, 11, 14 and 15, conform to the characteristics of highly radiogenic lead (HRL) in bronze vessels from Central China, for the values of ^{206}Pb/^{204}Pb and ^{208}Pb/^{204}Pb in these coins are above 19 and 40 respectively [53, 54].

In the light of the previous lead isotopic studies of ancient Chinese copper alloyed artifacts, the provenance of the HRL was initially estimated to be the mines distributed in southwest China [55, 56]. The source of common lead in this study is also open to this region, based on the recent published isotope database for the provenance study of archaeological materials [57]. These inferences are also consistent with the historical documents. *Records of the Huayang State* (*Huayangguo Zhi* 华阳国志) was written in the Eastern Jin dynasty (317 ~ 420), and is recognized as one of the earliest local chronicles specializing in ancient southwest China. This ancient work records that lead mines were found in Shu 蜀 (approximately modern Sichuan province) and Nanzhong 南中 (approximately modern Yunnan province) regions. These two regions together correspond approximately to the area under the administration of the Jiannan 剑南 circuit in the Tang dynasty (Fig. 1) [58]. In addition, Dugu Tao独孤滔, born in the late Tang dynasty, was quoted in *Compendium of Materia Medica* (Bencao Gangmu 本草纲目) vol. 8, as saying that the lead mines were located in Jiazhou 嘉州, Yazhou 雅州 and Jianzhou 剑州 prefectures, within the jurisdiction of the Jiannan circuit [58].

To be more specific, we chose the published lead isotopic data of galena ores from southwest China as comparators based on the above-mentioned historical records (Additional file 1: Table S3) [59–71]. These include the mine sites Tangjia 唐家, Tuanbaoshan 团宝山 and Ganluo 甘洛, which are located in the area of Jiazhou and Yazhou prefectures, as well as the mines of Huize 会泽 county, an area described as teeming with lead, silver and copper in *Records of the Huayang State*, and known as Tangxing 唐兴 in the Tang dynasty (Fig. 1) [58]. It can be seen in Fig. 5 that both Huize and Tuanbaoshan yield not only common lead but also HRL. The data of samples HM2, 4, 7, 9, 10 lie within the range of common lead from these two places. The data of HRL in HM 6, 8, 11, 14 and 15 overlap with one result from Huize, and locate within the range of the Huize lead mines, suggesting that the lead of these samples might be derived from this region. In brief, the data from Lafu queke matches the lead isotopic signatures of some lead mines in southwest China, which is also consistent with the historical records.

Monetary supply of the northwest borderland

Chen Zi'ang 陈子昂 (ca.659 ~ ca.700) was not only a famous poet in Chinese literary history, but also placed in a key position during the reign of Empress Wu Zetian 武则天 (684 ~ 705), as recorded in his biography in the *New Tang History*. In his memorial to the throne *Proposal for the military affairs of the Shu region* (*Shang Shuchuan Junshi* 上蜀川军事), he mentioned that the expenses

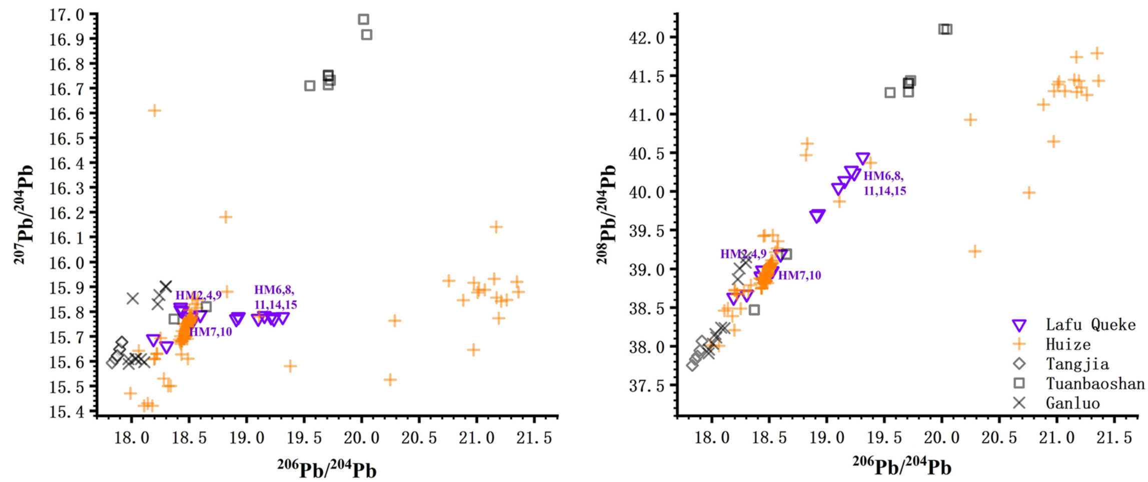

Fig. 5 Lead isotope ratios of the Lafu Queke samples and southwest China lead mines

for military affairs of the northwest borderland relied entirely on the southwest region [72]:

> *"The Ba-Shu 巴蜀 region is the land of abundance in our country. The military expenses 资, the supply of postal system, as well as the merchandise for the prefectures of the Longyou 陇右 - Hexi 河西 region, are all obtained from the Shu 蜀 region."*
> "……伏以国家富有巴蜀，是天府之藏，自陇右及河西诸州，军国所资，邮驿所给，商旅莫不皆取於蜀，……"

Longyou 陇右 was another circuit at the same administrative level of Jiannan in the early Tang dynasty, and it had jurisdiction over a vast area, including modern Gansu province and Xinjiang Uygur Autonomous Region (Fig. 1) [58]. Unfortunately, in such a context, it could not be confirmed whether the word "expenses 资" mean money or military goods, meanwhile, the money could be silk or coins, or both, at this time [73, 74]. For example, the unearthed documents in Turfan recorded a special type of silk for military expenses, named *junzi lian* 军资练 [75]. In A memorial from the Department of Public Revenue dated of the third year of the Yifeng reign of the Tang (678) and the resulting directive (zhifu旨符) issued to the Department of the Treasury (Jinbu 金部) of the fourth year (679) (Tang Yifeng Sannian Duzhi Zouchao Sinian Jinbu Zhifu 唐仪凤三年度支奏抄．四年金部旨符), it was stipulated that the tax silk paid by the Jiannan circuit was transferred annually to Yizhou 伊州 and Guazhou 瓜州 (in modern Gansu province) prefectures to support the military in the borderland [21].

Nevertheless, in Chen Zi'ang' s work *Proposal for national affairs* (*Shang Yiguoshi* 上益国事) [72], the word "expenses" 资 could mean bronze coins, as in the following passage:

> *"Exploiting copper from the mines in the mountains of Jiannan 剑南 circuit to mint coins could make our country rich. However, nowadays all the mountains are closed and no official mining is implemented. And all the military expenses 资 are levied from the common people. Thus, on the one hand, the government are exhausted and the people are impoverished. On the other hand, the natural resources are abandoned. As I see it, please reinstate the previous system 旧式 that exploited copper from the mines distributed in the prefectures of Jiannan circuit, and minted money in Yizhou 益州 prefecture, from which all the military expenses 资 for the Songpan 松潘 area (in the west of modern Sichuan province) could be obtained."*
> "……伏见剑南诸山多有铜矿，采之铸钱，可以富国。今诸山皆闭，官无采铸。军国资用，惟敛下人。乃使公府虚竭，私室贫弊。而天地珍藏，委废不论。以臣所见，请依旧式，尽令剑南诸州准前采铜，于益府铸钱。其松潘诸军所须用度，皆取以资给，……"

This passage confirms that in the era before Wu Zetian' s reign, Yizhou 益州 prefecture of the Jiannan circuit was an important base of coin production, as also corresponding to the aforementioned records in the *New Tang History* and *Institutional History of Tang*. Also, the mints in the Yizhou 益州 prefecture used the raw metal exploited locally in the Jiannan circuit. And, as there is no evidence to suggest that Chen Ziang was a specialist of minting coins, it is quite normal that he neglected the alloying components of coins. Thus, it could be estimated that, besides copper, the locally exploited raw metals could also include lead and tin.

In accordance with these conditions, it can be understood that the bronze coins minted in southwest China were largely made from indigenous metals, and supplied in large amounts to the northwest borderland of the Tang dynasty in the seventh century CE. Furthermore, the indications from the lead isotope ratios of the Kaiyuan Tongbao coins from the Lafu Queke cemetery strengthen the chain of evidence extracted from the historical materials.

The Tang dynasty played a critical role in the formation of the pluralistic and integrated pattern of the Chinese nation, not only because of its powerful strength and vast territory, but also because of its innovation of ruling ideology that began to regard the heartland and the borderlands as a whole [15, 76]. Deploying Kaiyuan Tongbao coins to the northwestern prefectures not only served as an important segment of the monetary supply network of the Tang empire, but also embodied China's internalized governance of the borderlands, and certainly exerted far-reaching influence on the region's political and economic situation.

Conclusion

In this paper, 15 Kaiyuan Tongbao coins of the early Tang dynasty excavated from the Lafu Queke cemetery in Hami city, Xinjiang Uygur Autonomous Region, Northwest China, were studied by multiple scientific methods. The XRF results show that all of these coins were Cu–Sn–Pb ternary alloy. The lead isotopic data indicate that the provenances for the lead material of the 14 coins are located in the Southern China geochemical province, and 5 coins contain HRL. Combining the scientific results with the archaeological context and the historical records, it can be inferred that the coins were first minted in southwest China by the locally exploited raw metal, and then supplied to Tang's northwest borderland in the seventh century CE.

Abbreviations

HRL: Highly radiogenic lead; PXRF: Portable X-Ray Fluorescence; MC-ICP-MS: Multicollector inductively coupled plasma mass spectrometry; TSP: Tombs with a sloping path; CVS: Catacombs with a vertical shaft; BG: Burials on the ground.

Supplementary Information

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Additional file 1: Table S1. Published chemical compositions data of bronze coins of the Tang dynasty. **Table S2.** Published lead isotopic ratios of bronze coins of the Tang dynasty. **Table S3.** Published lead isotopic ratios of galena from mines in southwest China.

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Author contributions

DM, YB and and WL wrote the main manuscript text and prepared tables and figures. YW selected the samples and offered archaeological context. JY authenticated the exact date of the samples. All authors reviewed the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Competing interests

We declare that we have no conflicts of interest to this work, we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and /or company that could be construed as influencing the position presented in or the review of the manuscript entitled.

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