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Provenance Study of Sancai Glazed Pottery Excavated in Longhai Royal Tomb of Bohai State by Composition and Statistical Analysis

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Abstract:

The views about the provenance of Sancai glazed pottery discovered in Bohai State are distinct. The purpose of this research is to measure the Sancai glazed pottery samples excavated in Longhai royal tomb of Bohai state by X-ray fluorescence, and then comparative analyse the compositions data of this research with Tang Sancai from the Huangye kiln, Huangbao kiln and Liquanfang kiln in Tang Dynasty in the Central Region of China. The results show that chemical composition of the body and the glaze applied in this research is different from the samples of the above three main kilns in the central region of China. Therefore these samples excavated in Longhai royal tomb of Bohai state are presumably produced in Bohai state locally.

Keywords: *Bohai state, Longhai royal tomb, Sancai glazed ceramic, Tang Sancai, provenance.*

I. INTRODUCTION

Sumo Mohe family founded Bohai State between AD 698 to 926 years, whose dominion was a majority of the northeast of China and parts of the northeast of Korean peninsula as well as Russia's Primorsky Territory. Archaeological surveys and excavations indicated that there were multiple burial areas in Bohai state, such as Liuding Mountain site in Dunhua, Jilin Province, Longtou Mountain site in Helong, Jilin Province and Sanleng Village site in Ning'an,

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Heilongjiang Province. The samples considered in this research are part of Longhai Bohai imperial tombs, which belong to Longtou Mountain tombs site. The overall length of Longtou Mountain is about 7.5 kilometres and can be divided into Shiguo tombs, Longhai tombs and Longhai tombs from south to north. The Longhai tombs locate in the middle of the Longtou Mountain tombs site and are the most important tombs. There were trio-coloured glazed pottery of the Tang Dynasty excavated in the tombs named M3 and M10. The M3 tomb is large and in the form of stone chamber, and the epigraph reveals that the tomb attributed to Shunmu empress, while the M10 is a large brick room tower tomb [1].

It's known that the Sancai glazed pottery of the Tang Dynasty is coloured pottery with greenware clay and embellished by low-temperature lead glaze, which was prevalent in the Tang Dynasty as burial objects for royalty and nobleman [2]. Historical materials recorded that the Bohai State had been on intimate terms with Tang Dynasty since it was founded. They advocated the system of Tang Dynasty and learnt the advanced production technology of Tang Dynasty actively, and the firing of the Sancai glazed pottery may also be included. The origin of Sancai glazed pottery unearthed in many sites of Bohai sate has been followed with interest by numerous researchers [3]. The number of Sancai glazed pottery unearthed increased with the archaeological excavations increasing. The discovery of a certain number of building compositions type glazed pottery was very critical. Many researchers considered that the building compositions type glazed pottery and Bohai form glazed pottery were produced in local Bahai state, and the Central Plains form glazed pottery, such as the Sancai figurines, etc., should be from the Central Plains[4, 5].

The main kilns of Sancai glazed pottery of the Tang Dynasty were Huangye kiln in Gongyi, Henan Province, Huangbao kiln in Yaozhou, Shanxi Province and Liquanfang kiln Changan, Shanxi Province. Some researchers had been studying many samples of the three kilns mentioned above so far. In contrast, the composition of Sancai glazed pottery from the Bohai state had only been analysed by Japan researcher Yamazaki Kazuo and Russia researcher E. Gelman. The samples analysed by the former were bowls of glazed collected by Mikami Jio before 1949 A.D., and the glaze was detected[6], while the samples analysed by the latter were 18 pieces of pottery glaze layer of Sancai glazed pottery excavated in Russia [7]. There had no systematic research of Sancai glazed potteries excavated in Bohai state till now in China. It follows that they are significant for the comparative analysis of Sancai glazed potteries excavated in imperial tombs of Bohai state with samples of the main kilns of Sancai glazed pottery of the Tang Dynasty and exploring the material and technology relationship between them.

II. SAMPLES AND MEASUREMENTS

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2.1 The Samples

Four pieces of samples were selected in this measurement (Fig 1). Three were incomplete bodies of human tomb figure, and one was the head of a horse tomb figure. All of the three human tomb figures were from tomb 10(M10), whose serial numbers were CY-7, CY-8 and CY-13, while the head of a horse tomb figure was unearthed in tomb 3(M3), numbered MT.

Fig 1: Sancai sherds from Longhai Bohai royal tomb used as samples

2.2 Measurements

The glaze compositions of these samples were measured by the Energy-dispersive X-ray fluorescence spectrometer (Shimadzu Corporation, EDX-720) after washed by deionised water and absolute alcohol. A piece of each sample was sliced and got rid of glaze and then ground into particle size less than 0.053mm.The body compositions of these samples melting were measured by wavelength dispersive X-ray fluorescence spectrometer (PANalytical, Axios-Minerals) following the melting method.

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III. RESULTS AND DISCUSSIONS

3.1 The Composition Analysis of Glaze

The chemical compositions of the glaze of the above samples are shown in Table 1. The chemical compositions of the four samples illustrate the main constituents of the glaze are PbO and SiO2. There is a certain amount of Al2O3 in samples CY-8 and MT, predicating that the glaze of these samples excavated in Longhai royal tombs of Bohai state attribute to PbO-SiO2 and PbO-Al2O3-SiO2 group system. There is a bit of Ca and K as rhodolite in addition, increasing the stabilisation of the glaze and combine degree of greenware and glaze [2]. The results of previous studies instruct that the colourant of green glaze of Sancai glazed pottery is CuO, and the colourant of the yellow ones is Fe2O3 [2]. The glaze colour of the sample CY-8 is green, and whose CuO content in chemical composition of glaze exceeds the other three samples. It conjectures that the colorant of this sample CY-8 is possibly CuO. The glaze color of sample CY-13 is yellowish-brown, and Fe2O3 is occupied 6.874% of the chemical composition of the glaze of the sample, which exceed the remaining samples, illustrating that the colorant of this sample CY-13 may be Fe2O3. It follows that the main coloring elements of Sancai glazed potteries excavated in imperial tombs of Bohai state are transition elements such as Cu and Fe.

TABLE 1 Chemical element composition in the glaze of samples (WT %)

Samples	PbO	SiO_2	Al_2O_3	CaO	Fe_2O_3	K_2O	CuO	TiO_2
CY-7	70.709	20.455	-	4.357	2.671	0.768	0.665	-
CY-8	55.1	23.203	6.654	6.861	3.442	1.647	1.966	0.976
CY-13	73.914	14.803	-	3.433	6.874	-	-	0.976
MT	78.021	15.038	2.266	0.678	3.055	0.523	0.192	-

The data of Table 1 displays that the content of PbO in the glaze of Sancai glazed potteries excavated in imperial tombs of Bohai state is 55.1%~78.021%, however which is 55.1%~78.021% of Sancai glazed potteries of Bohai state considered by E. Gelman[7], and the date reported by Yamazaki Kazuo is 64.1%, 67% and 67.4%[6]. Obviously, the content of PbO in the glaze of samples considered by former researchers and mentioned in this research are approximate. Some literatures reveal that the contents of PbO in glaze of hangye kiln, huangbao kiln and liquan kiln are 33.22%~54.48%, 43.88%~66.79%, and 44.2%~46.5% [8,9,10]. The content ratio of PbO and SiO2 (PbO/SiO2) of Central Plains Sancai glaze pottery of the Tang and Liao Dynasty[2] and Sancai glaze pottery excavated in Bohai state is exhibited in box-type figure(Fig 2). It is indicated that the ratio of PbO and SiO2 in the glaze of Sancai glaze pottery

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excavated in Bohai state is higher, the average value slightly greater than 4, while which of the other three kilns is lower, approximately around 1~2, and the difference of the two is notable. It is illustrated that the proportioning methods between the Sancai glaze pottery excavated in Bohai state and the other three kilns in central plains are probably diverse.

It is illustrated in figure 2 that the ratios of PbO and SiO2 in glaze of Sancai glaze pottery of Liao Dynasty and Tang Dynasty are extremely approximate, both of which are between 1~2, and is obvious difference with Sancai glaze pottery excavated in Bohai state. It is generally believed that the Sancai glaze pottery of Liao Dynasty is the evolution from Tang Dynasty. However there is no discovery of blue glaze appeared in Sancai glaze pottery of Tang Dynasty in Sancai glaze pottery of Liao Dynasty, on the contrary the Sancai glaze pottery of Liao Dynasty is a certain extent likeness to Sancai glaze pottery excavated in Bohai state, both of which basically applied yellow, green and white glaze. A large number of adherents of Bohai State moved to the hinterland of the Liao state after Bohai state was destroyed by Liao state. Currently researches have indicated that adherents of Bohai State influenced the manufacture of pottery and glazed pottery in forepart of Liao Dynast [5]. It is required further research to reveal what have been influenced by Sancai glaze pottery of Bohai state during production process in Sancai glaze pottery of Liao Dynasty.

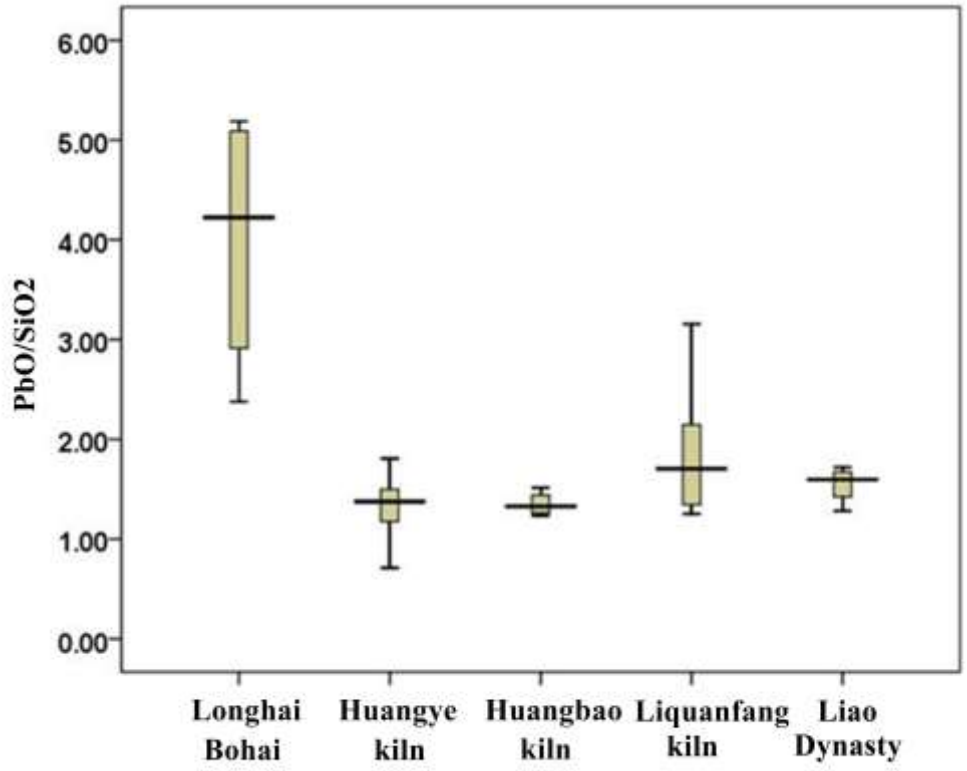

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Fig 2: Boxplots of the result of PbO/SiO2

3.2 The Composition Analysis of Pottery Bodies

The data of Table 2 displays that the chemical compositions of pottery bodies. Factor analysis of data measured and data of huangbao kiln and huangye kiln measured by Baoping Li was applied by SPSS statistics software. The element Ba, Cr, Cu, Nb, Sr, V and Y were employed to receive a credible figure of KMO (Kaiser-Meyer-Olkin measure of sampling adequacy), which is 0.71, illustrating the samples selected are suitable for factor analysis [11]. After calculating, the first principal divisor F1 and the second principal divisor F2 separately occupy 62.235% and 22.6% of the informational capacity (the sum of the characteristic of the samples reflected by all the seven elements), meaning the above two principal divisors represent 84.835% of the informational capacity, basically reflecting all the information of dates analysed. Figure 3 was a scatter diagram of factor analysed above.

TABLE 2 Element composition in body of samples

	CY-07	CY-08	CY13	MT
SiO_2	58.39	57.73	62.39	72.84
TiO_2	0.93	0.90	0.87	0.87
Al_2O_3	31.77	32.80	28.13	19.48
TFe_2O_3	1.60	1.54	1.6	2.44
MnO	0.01	0.01	0.01	0.02
MgO	0.35	0.30	0.3	0.45
CaO	0.64	0.78	0.65	0.32
Na_2O	0.34	0.33	0.4	0.34
K_2O	1.58	1.11	1.9	2.18
P_2O_5	0.09	0.15	0.16	0.04
LOI	3.24	5.15	4.02	1.18
Ba	323	300	291	376
Co	4	8	6	2
Cr	18	20	16	34
Cu	178	157	95	139
Ga	42	43	36	29
Nb	13	12	13	21
Ni	8	19	15	9
Pb	1335	272	1354	596
Rb	109	88	123	143
Sr	64	72	57	50
V	81	75	50	64
Y	17	34	18	35

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Zn	59	106	62	73
Zr	311	313	362	262

Notes: LOI is loss on ignition, principal composition content is 10^{-2}, trace principal composition content10^{-6} in the analytic results.

Comparative analysis of trace elements was applied between data measured and data of liquan kiln published by CUI Jian-feng et al.. Ba, Cu, Sr, Y, Zr and Zn are used as Factor variables, the KMO is 0.568, indicating that the factor analysis is authentic. After calculating, the first principal divisor F1 and the second principal divisor F2 separately occupy 39.543% and 24.3% of the informational capacity (the sum of the characteristic of the samples reflected by all the six elements), meaning the above two principal divisors represent 63.843% of the informational capacity, which is still representative [9]. Figure 4 is a scatter diagram of this factor analysis.

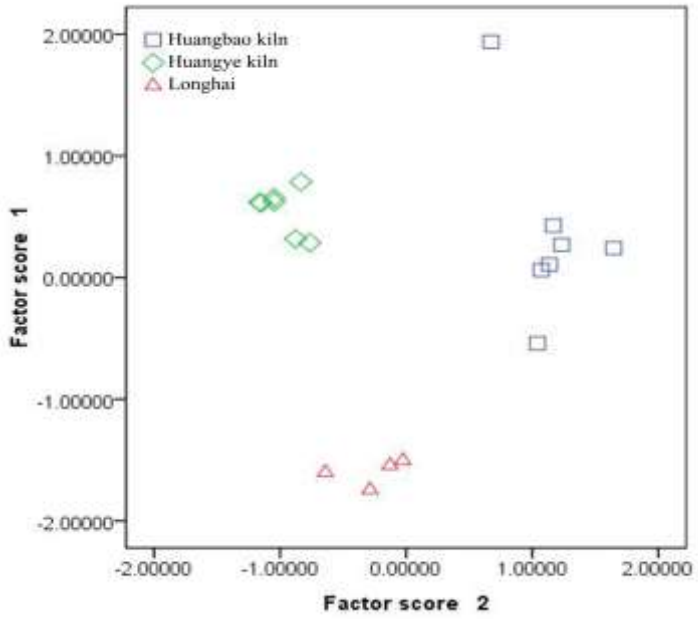

Fig 3: the result of factor analyse of samples from Longhai, Huangbao kiln, and Huangye kiln

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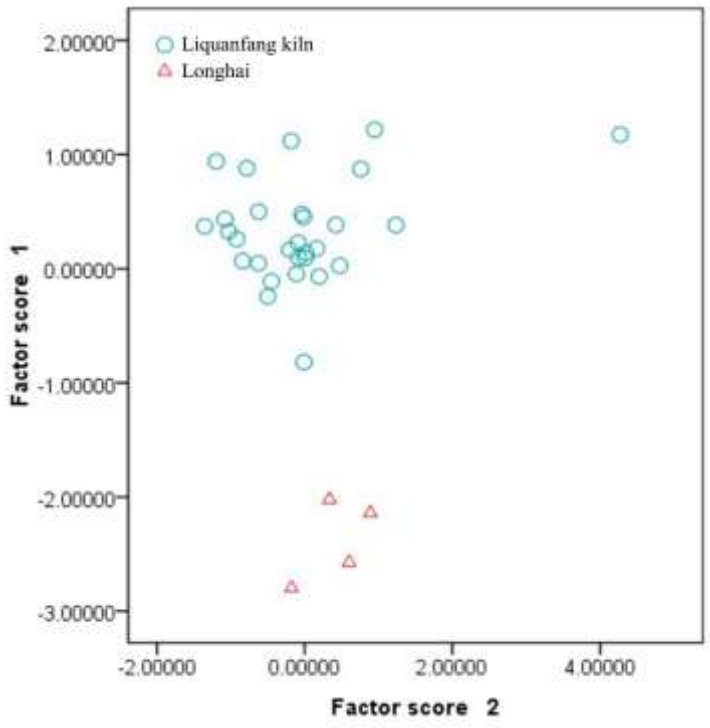

Fig 4: the result of factor analyse of samples from Longhai and Liquanfang kiln

The trace elements are mineral accompanying elements whose contents could be influenced by diverse formation methods of minerals and surroundings change, consequently which frequently applied as ore source indicator. The trace elements and their contents of raw material are substantially independent of the technical procedure, burial environment and weathering during the firing process of ceramics, accordingly which are commendably capable of reflecting the origin characteristics of the raw material. The analytic result of multivariate statistic indicates that the dates of trace content in-person tomb and horsehead figures of Sancai glazed pottery unearthed in the Longhai Bohai royal tomb are significant difference from the samples of huangye kiln, huangbao kiln and liquanfang kiln in central plains of China. It intimates that the source of pottery body material of the four samples measured is diverse with the above three kilns in central plains.

The explores of Longhai Bohai royal tomb propose in excavation bulletin that the style of male and female tomb figures of Sancai glaze pottery is approximately analogical, while there are slight disparity in some aspects, for instance the appearance of male and female tomb figures of Sancai glaze pottery of Bohai state is taller and thinner than which of Sancai glaze pottery of Tang Dynasty, and the scale of body parts is more modest. Furthermore the pedestals of tomb figures of Sancai glaze pottery of Bohai state are larger, assuming circular or oval, the skirt

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located in the central section, however the pedestals of tomb figures of Sancai glaze pottery of Tang Dynasty are larger, hardly appearing circular or oval, the skirt located in the edge section. The elements content both of body and glaze of the Sancai glaze pottery of Bohai state is noticeable variant with the Sancai glaze pottery of Tang Dynasty of huangye kiln, huangbao kiln and liquanfang kiln. Their appearances are generally propinquity; nevertheless, there are specific distinctions in details. Accordingly, the Sancai glaze potteries excavated in Longhai Bohai royal tomb probably produced in Bohai state locally, while there have no kilns of firing Sancai glaze pottery or porcelain been discovered in Bohai state, except the kilns of pottery and tile. Consequently further researches are required to reveal the specific kilns of Sancai glaze potteries excavated in Longhai Bohai royal tomb.

IV. CONCLUSIONS

In summary, the chemical elements composition in the glazes and bodies in this research is notably different from the samples of the three main kilns: huangye kiln, huangbao kiln and liquanfang kiln in the central region of China. Meanwhile, the composition in the glazes parallels the data of Sancai glazed pottery of Bohai state detected by former researchers. It indicates that there may be similar methods of matching raw material of the Sancai glazed pottery of Bohai state and which is distinct from the three kilns in central plains. Therefore, the Sancai sherds from Longhai Bohai royal tomb should be produced locally in Bohai State.

This study revises the old concept of the Central Plains form glazed pottery, such as the Sancai figurines in Bohai state should be from the Central Plains in Tang Dynasty. Our results suggest that Sancai figurines with Central Plains form were produced in local Bahai state as the building compositions type glazed pottery and Bohai form glazed pottery.

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