A Case Study of Sedimentary Characteristics of Archaeological Strata Archived on Site: Tianmen, Jianghan Plain

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***Abstract* — Based on detailed analyses of multi-proxies such as AMS^{14}C dating, grain size, and micro-morphology of zircon, we study the sedimentary characteristics of archaeological strata archived in Tianmen in Jianghan Plain. The research indicates that the early Shijiahe cultural layer at the bottom of the Tanjialing Site is a paleo-flood related lacustrine sediments generally after the weaker hydrodynamic transport process. During the early Shijiahe cultural period, the Tanjialing Site was still an area where there were many rivers, lakes and swamps. The unearthed paleo-woods of the early Shijiahe cultural layer also suggest that the site area was still affected by floods, but there was no paleo-flood deposit left. The reason is that only when every level of flood events is higher than or equal to the ancient surface of Tanjialing Site, can paleo-flood deposits be retained. The subsequent natural denudation or human activities may make paleo-flood deposits absent or their thickness change.**

Keywords - Jianghan Plain; Tanjialing Site; sedimentary characteristics; grain size; micro-morphology of zircon

I. INTRODUCTION

Research of global change science is a hot topic in international academic community nowadays [1], and the man-land interrelations are an important content in global change research [2-4]. The strata of archaeological sites are an important information carrier, so the research into the archaeological strata has become an important aspect in the research of man-land relationships [5]. In recent years, a number of protective archaeological excavations have been conducted in the Jianghan Plain, Hubei. We took part in the excavation of Tanjialing Site in Tianmen City, which was coordinated by Hubei Provincial Institute of Cultural Relics and Archaeology. In this paper, comparative research of AMS^{14}C dating, grain size and micro-morphology of zircon was performed to reveal sedimentary characteristics of archaeological strata in the Tanjialing Neolithic Site.

II. SITE DESCRIPTION AND SAMPLING

The Tanjialing Neolithic Site is situated in the center of Shijiahe town (Fig. 1), Tianmen City, Hubei Province, and geographically lies in the north-central Jianghan Plain area (GPS 30°46′17.39″N, 113°04′48.27″E, and 33 m above sea level). A freshly clean exposed profile, in the south wall of T0620 (Fig. 1), was sampled for analysis. The study profile is 330 cm in thickness and divided into nine lithological horizons composed of two distinctive sedimentary units: the upper cultural layers and the lower 9th mud layer. Charcoal at the depth of 180 cm in the Tanjialing Site was submitted for AMS^{14}C dating at the Laboratory of AMS-^{14}C Sample Preparation, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, and the State Key Laboratory of Nuclear Physics and Technology, Peking University. The AMS^{14}C dating with 2σ calibration is 4356±70 cal. a BP [6], indicating that the age of the 9th layer in the Tanjialing Site is 4.6~4.4 ka BP, which is attributed to the early Shijiahe Culture [7]. 61 samples were then collected in the 9th layer (215~330 cm) for grain size analysis, and 4 samples in the whole profile for micro-morphological analysis of zircon.

III. SEDIMENTARY CHARACTERISTICS OF ARCHAEOLOGICAL STRATA

The investigation on the spot reveals that the 9th black mud layer at the bottom of the Tanjialing Site unearthed many artifacts with features of early Shijiahe Culture, such as unique black potteries and red potteries, etc. This is distinguished to those of the Zhongba Site, whose mud layers contain no cultural relics [8]. The thickness of the 9th layer ranges between 100 cm and 115 cm, with darker colour. No significant vertical change in grain size, colour, texture and structure can be found. There are many plant charcoals and paleowoods unearthed in this layer, but there is no typical sedimentary feature of paleoflood deposits such as disturbance ripples and horizontal beddings. Therefore, the 9th layer may be lacustrine sediments, for the river flooding deposit should be composed of silt or silty-fine sand with light colour and less organic matter [9-10]. The colour of the 9th layer is rather dark with higher organic matter content. Nevertheless, the lacustrine sediments can also be related to the paleofloods, but it is not the direct deposition of flooding.

A. Grain Size

Grain size parameters were analysed using the Malvern Mastersizer 2000 laser analyser at the School of Geography Science, Nanjing Normal University, which can indicate sedimentary environments (Fig. 2). In the 9th layer, clay (< 4 μm) contents range between 21.01% and 43.05%, with an average of 30.59%, while silt (4~63 μm) contents range between 51.11% and 74.47%, with an average of 63.8%. The content of sand (> 63 μm) ranges from 0.42% to 18.50%,

with features of larger variation. There are three peak values and large variations at the depth of 240~250 cm, 280~290 cm, and 310~330 cm. As can be seen, the sediment of the 9th layer belongs to the clayey silt. The sand contents are mainly lower than 10%, indicating a weaker sedimentary dynamic feature. Otherwise, three peak values may suggest three stages with relatively strong hydrodynamic conditions.

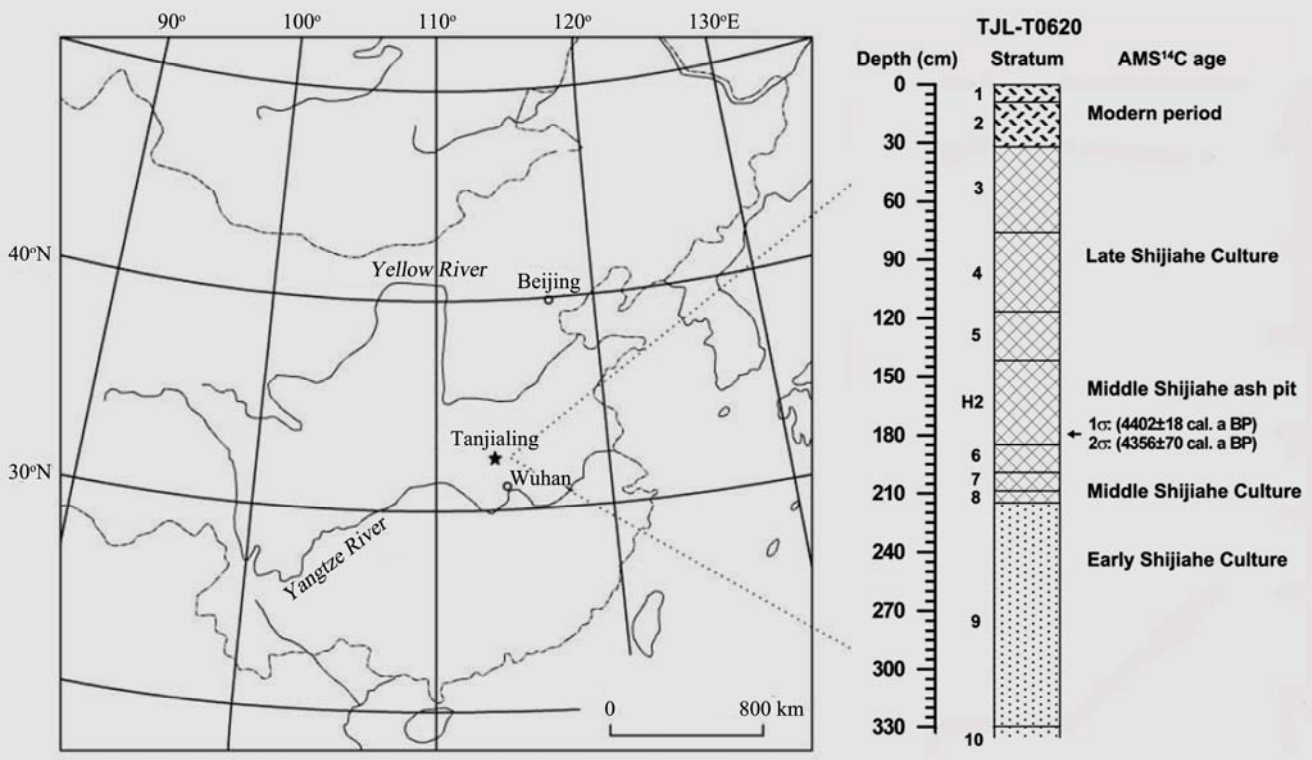

Figure 1. Geographic location and stratigraphic profile of the Tanjialing Neolithic Site.

From Figure 3, we can see that, frequency distribution curves show a consistent pattern of 3 peak values at different depths of the 9th layer's sediments. The main peak is within the range of 10~30 μm, with their contents of 3.5%~6%. The secondary peak is within the range of 0.6~1.0 μm, with their contents of 1%~2.5%. The third peak is within the range of 300~500 μm, with their contents of 0.6%~2%, which only appears in some depths and is characterized by sandy size fraction. There are many differences between the 9th mud layer and the flood deposit layer of the Hanjiang River. The kurtosis of modern flood and paleoflood deposit layers from the Hanjiang River is narrow, showing a pattern of one peak [11-13]. Otherwise, as to content of grain size fraction, all of the samples are mainly composed of suspended matter. Only less than 10% of saltation components exist in samples, and there is no rolling component. All of these represent an overall weak hydrodynamic depositional environment, with different material sources of the Hanjiang River. In view of the wide distribution range of grain size, fine grain size, rich organic matters and complex material sources of lacustrine sediments, combined with the field investigation and above grain size analysis, we believe that the Tanjialing Site area may experience a shallow lake environment, with moderate flow velocity and certain water range. However, some peak values of sand in the layer also indicate that these lacustrine sediments may be related to the paleofloods, because of the stronger hydrodynamic conditions of floods. But it should not be the direct deposition of flooding.

B. Micro-morphology of Zircon

Zircon is a kind of heavy mineral with large density and hardness, which makes it very resistant from erosion force. Therefore, examining the surface micro-morphology of zircon is an important method to judge the sedimentary characteristics. From Table I we can see that the micro-shapes of zircon in unit T0620 are mainly spheral, cubic dipyramid or double cubic dipyramid. The origin shape of cubic dipyramid reaches the highest in the whole site strata (54.24%~59.82%), and the shape of columnar and well rounded only ranges between 5.68% and 30.11%. Most importantly, the shape of columnar only ranges between 15.38% and 27.83% in the 9th mud layer during the early Shijiahe cultural period, which is much lower than the 1981 flood deposits at the Zhongba Site (55.36%) and the 2004 flood deposits at the Yuxi Site (60.92%) in the upper Yangtze River [8, 14, 15]. The well rounded shape also only ranges between 3.85% and 6.60% in the 9th mud layer. Correspondingly, there are no significant differences of the origin zircon shape of cubic dipyramid between upper cultural layers and the 9th mud layer. Meanwhile, the shape

of double cubic dipyramid and tetragonal prism accounts for 2.06%~4.55% and 3.29%~7.69%, respectively. As a whole, the origin shape of zircon is the dominant in the layers of the Tanjialing Site.

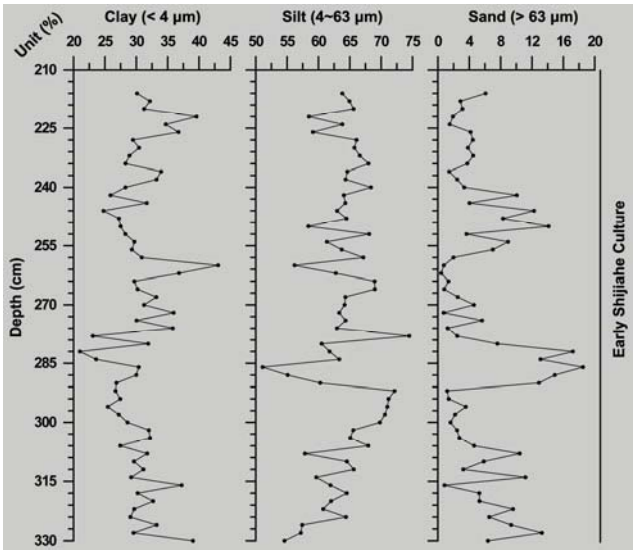

Figure 2. Percentage variation of clay, silt and sand in the Tanjialing Profile.

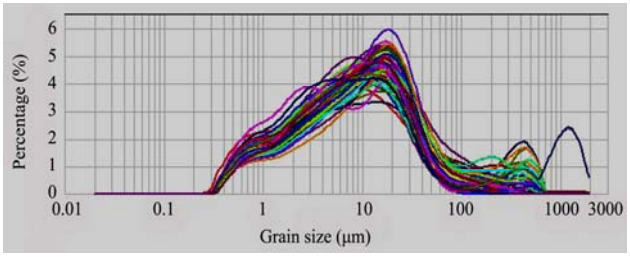

Figure 3. Frequency distribution curves of samples from the 9th mud layers in the excavation unit T0620 of Tanjialing Site.

Figure 4 shows that zircon shapes in the samples of the Tanjialing sediments are obviously original cubic dipyramid, which are different from those in the paleoflood or modern flood layers from the Zhongba Site and the Yuxi Site [8, 14, 15]. This difference is caused by the weak hydrodynamic handling with features of near provenance. Most of zircons in the samples of the lower 9th mud layer are not abraded into orbicular shape, keeping ribbed features. So, there are resemblances on the shapes of zircon between the 9th mud layer and other cultural layers in the Tanjialing Site. From above multi-evidences of grain size analysis and micro-morphology of zircon, we verified that the 9th early Shijiahe cultural layer at the bottom of Tanjialing Site is a paleoflood related lacustrine sediments generally after a weaker hydro-dynamic transport process. Also it should not be the typical paleoflood deposits and the direct deposition of flooding.

TABLE I. ZIRCON SHAPES FROM UNIT T0620 OF TANJIALING SITE

(I-1)

No.	Depth (m)	Columnar (%)	Well Rounded (%)	Cubic Dipyramid (%)
5-74	1.40	29.22	3.70	61.73
H2-66	1.80	30.11	5.68	56.25
9-57	2.18	27.83	6.60	55.66
9-6	3.20	15.38	3.85	69.23

(I-2)

No.	Double Cubic Dipyramid (%)	Tetragonal Prism (%)	Total
5-74	2.06	3.29	243
H2-66	4.55	3.41	352
9-57	4.25	5.66	212
9-6	3.85	7.69	26

Figure 4. Comparison of zircon shapes from the deposit layers in unit T0620 of the Tanjialing Site.

IV. CONCLUSIONS AND DISCUSSION

On the basis of archaeological strata and AMS^{14}C dating, multi-proxy evidences indicate that the 9th early Shijiahe cultural layer at the bottom of Tanjialing Site is a paleoflood related lacustrine sediments generally after a weaker hydro-dynamic transport process. The area of the Tanjialing Site in Tianmen still belongs to the center position of the Luohansi irrigated area of the Hanjiang River. Thus, there are close relationships between the 9th mud layer at the bottom of the Tanjialing Neolithic Site and Hanjiang River floods during prehistoric era. The initial purpose of the Shijiahe city wall construction in Tanjialing Site may also be close related to the threat of Hanjiang River floods. In the early Shijiahe cultural period, the Tanjialing Site was still an area where there were many rivers, lakes and swamps. The unearthed paleowoods of the early Shijiahe cultural layer also suggest that the site area was still affected by floods, but there was no paleoflood deposit left. The reason is that, only when every level of floods is higher than or equal to the ancient surface of the Neolithic site, can paleoflood deposits be retained. Due to the low water level and deposit position, normal paleoflood deposits have often been eroded by subsequent floods, and cannot be long-term preservation. Only the great flood covered ancient landform surface of the site, can relatively thick paleoflood deposits be retained in

archaeological strata. The subsequent natural denudation or human activities may make paleoflood deposits absent or their thickness change.

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