Article ID: 1673-1719 (2006) Suppl. 1-0064-04

Abrupt Climate Change from Pre-Xia to Xia Dynasty and the Formation of Ancient Chinese Civilization

Wang Shaowu

Department of Atmospheric Science, School of Physics, Peking University, Beijing 100871, China

Abstract: The abrupt climate change of wetness in China from 2100 BC to 1800 BC is examined according to historical documentations, archaeological evidences and palaeo-climatic proxy data. The results show that there was a period with predominance of floods before the foundation of the Xia Dynasty (2070 BC). The folklore of "Regulation of floods by Great Yu" marked the ending of the period with floods. Climate turned to dry around the establishment of the Xia Dynasty. There are evidences to show that the annual precipitation reduced by 20% within a period less than 300 years. This change may be acknowledged as an event of abrupt climate change. The evidences show that change from wet to dry condition probably caused the collapse of archaeological cultures in China except in the central part of the main land area, where development of Chinese civilization leaded to the foundation of the Xia Dynasty.
Key words: Xia Dynasty; abrupt climate change; ancient Chinese civilization

Introduction

Technology of Chronology of Xia, Shang and Zhou Dynasties, 1996−2000 [1] confirmed that the Xia Dynasty founded in 2070 BC. Most of the historians agreed in that the era of civilization in China began at the Xia Dynasty [2−3]. Since then came the splendid historical period of the three Dynasties in China.

Present paper studies the abrupt climate change around the foundation of the Xia Dynasty and the possible impact on the development of civilization in China. It is needed to emphasize that the abrupt climate change was an abrupt change of wetness.

1 Archaeological evidence of the climate over the Neolithic Age

Neolithic Age began at the beginning of the Holocene. It is generally acknowledged that the Neolithic Age in China started in 10.0 ka BP (^{14}C years①). The four thousand years of 8.0−4.0 ka BP were the most important period in the Neolithic Age [4−5], which can be divided into three sub-periods: Pre-Yangshao Culture (8.0−7.0 ka BP), Yangshao Culture (7.0−5.0 ka BP) and Longshan Culture (5.0−4.0 ka BP). The Pre-Yangshao Culture is characterized with rapid development of agriculture. It infers that climatic conditions were favorable to growth of the corp. However, the ruins of Pre-Yangshao Culture were mainly found in the boundary between the plain and hills, the size of the boundary was limited, the thickness of sediment was relatively thin, the remains of grain were the millet [4], which is the drought-resistant plant. It means that the climatic conditions were not perfectly satisfactory [5]. Pollen data showed that this time just began the Holocene Megathermal [6].

Archaeological Yangshao Cultures were widely spreaded over the mainland area of China. Peoples were settled down with mature development of agriculture. Chronology study on the ruins of archaeological cultures in Shaanxi during the Neolithic Age indicated that maximum frequency appeared in 6.5−6.0 ka BP. The maximum frequency of ^{14}C years of excavated grain was also found in 6.5−6.0 ka BP. It proved that climate conditions were most favorable in the Yangshao Period [7]. Pollen analysis indicated that it is the core period of the

Received: December 22, 2005; revised: March 17, 2006
Corresponding to Wang Shaowu (E-mail: swwang@pku.edu.cn)

① ^{14}C years are the date before 1950 AD, calendar years are shown by BC

Megathermal [6].

The Longshan Culture appeared in the five millenniums before present. Archaeological chronology study indicated that the beginning of Longshan Culture varied from 4.8−4.5 ka BP. It consisted of a series of sub-types of archaeological cultures. However, the coverage of Longshan Culture was less than that of Yangshao Culture, and the density of archaeological ruins was also lower in the Longshan period than in the Yangshao period. The ^{14}C dating analysis of the excavated grain showed that the frequency of dating sites was reduced by 50% in 5.0−4.0 ka BP, comparing to that during 7.0−6.0 ka BP [7]. It means that the climate during the Longshan period was worse in comparing to the Yangshao period. Temperature series reconstructed using pollen data indicated that temperature started decreasing during the Longshan period, though it still remained in the period of the Megathermal. A cold event occurred in 4.0 ka BP, which accelerated the ending of the Megathermal [6].

The Megathermal lasted for 4500 years from 8.0 ka BP to 3.5 ka BP in China [6], and was the core period of Neolithic Age, when the ancient civilization in China had gone from gestation to mature.

2 Emergence of Chinese ancient civilization and abrupt climate change

Zhou [2] has indicated that China had entered the period of civilization in the Xia Dynasty. Jiang [3] has synthesized the latest data about the development of ancient civilization in China. In the second part of the Shang Dynasty, the King Pangeng moved the Capital to Yin in 1300 BC. Handicraft workshops appeared in the Capital. It means that the Capital had become a relatively large city. Fine bronze wares were numerously made. More than one huandred thousand pieces of bones and tortoise shells have been excavated, on which a lot of inscriptions were carved, among them about 5000 characters have been identified. It shows that the Chinese characters in that time attained the mature stage of the development. All of the evidence outlined above indicated that Chinese civilization had entered the mature phase in the second part of the Shang Dynasty.

The first part of the Shang Dynasty started from Tang, the King who had established the Shang Dynasty in 1600 BC. Archaeological evidence showed that the Shang's cities in Zhengzhou and Yangshi were probably the capital of the Shang as called as "Bo", where a square wall was found around the city, and temples and palaces were found within the city. A lot of bronze wares were cached outside of the city, including big round tripods and square quadrupeds, a series of sacrificial wares, and a lot of bronze weapons. Two pieces of bone were found, on which some characters were carved. It proved that Chinese characters were appeared in the first part of the Shang Dynasty. One can conclude that civilization was well developed in the first part of the Shang Dynasty.

Now, it is widely acknowledged that the first four phases of Erlitou Culture belong to the Xia Culture. However, ^{14}C dating indicated that the first phase appeared ca. 19th century BC. It lagged much behind the beginning of the Xia Dynasty (2070 BC). But ^{14}C dating also showed that the late part of Longshan Culture (the 4th and 5th phases of Wangchenggang Culture) ranged between 2050−1985 BC and 2030−1965 BC, respectively. Therefore, it belongs also to Xia Culture. In the ruins of Erlitou Culture, there were the ruins of large palace, where probably fetes, meetings, and liturgies might be held and political orders announced. Outside of the city the ruins of bronze foundry workshops were also found. A lot of bronze wares were excavated. Totally 24 signs were identified on the pottery, which were probably the primitive characters in that time. All of the evidences indicated that the Xia Dynasty had entered the emerging stage of ancient Chinese civilization.

Examination of temperature changes during the last ten thousand years indicated that ancient Chinese civilization was growing in the period of Megathermal [6]. Of course, the warm and wet climate was favorable to survival of mankind, and it created nessassary conditions for the development of civilization. However, the evolution of civilization not only depend on the largescale climate background, but also on the abrupt climate change, for example, the cold-dry events lasted for generally several hundred years also accelerated the development of civilization. Especially in 4.0 ka BP, the abrupt climate change from wet to dry condition had taken part in hastening the parturition of ancient civilization in China.

3 Historical and palaeo-environmental evidence of floods in the Pre-Xia times

Shi-ji — *Xia-Ben-ji* (historical records — history of the Xia Dynasty) has recorded the floods over the time of Yao, who was the King before Shun and Yu. It was indicated that the Yu, who has laid the foundation of the Xia Dynasty, and regulated the floods, spending 13 years on the field and giving up the opportunity to go home three times [4]. There are a lot of historical records, in which the story of "Regulation of floods by Great Yu" are described in detail.

The struggle against floods of chiefdoms of Yan and Huang with supports from chiefdoms of Dongyi might not be limited in the period of Yu, and probably lasted about a few hundred years in the archaeological Longshan Culture period, including the periods of Yao, Shun and Yu in ca. 2500−2000BC [3]. The Yellow River has changed its course in ca. 4.0 ka BP. It flowed through the north plain of Huaihe River and emptied to the Yellow Sea before 4.0 ka BP, and flowed through Hebei plain and emptied to the Bohai Sea later. The change of the course to the north may mitigate the impact of floods in central part of Chinese mainland area. Historian Xu has examined the floods in detail in his book *The Legend Period of Ancient History in China* [8]. He indicated that the floods occurred in the late of the third millennium BC in the partial area of Yanzhou, Yuzhou and Xuzhou, that is in the middle and lower reaches of the Yellow River at present.

Some one thought that the floods were not limited over the Yellow River Valley. On the contrary, some one suggested that the floods were limited only at Yanzhou in west part of Shandong. Xu [8] indicated that the floods might have occurred not only in the Yellow River Valley but also other areas. However, the regulation work of floods were limited mainly in the aforementioned areas. Therefore, one cannot rule out the possibility of the occurrence of floods over the lower reaches of the Yangtze River. It needs to study further the area suffered from floods with more palaeo-climate data. But there are strong evidences, which supported the occurrence of the floods in the late of the third millennium BC.

Some one has challenged the regulation work of Yu, for no relative ruins of irrigation work are found untill now. Xu [8] indicated that the scale of the irrigation works in 4.0 ka BP was not comparable to that at present time. The geographical conditions 4000 years ago differed far from that in nowadays, while a lot of lakes occurred in east China, for example, about 50 lakes have been found in the region east of Taihang Mountains and north of Yellow River. Xia *et al*. [9] have indicated the predominance of floods around 4.0 ka BP in northern China after synthesizing the palaeo-climatic data and archaeological evidence from Qinghai, Gansu, Shanxi, and Beijing.

4 Climatic proxy data, environmental and archaeological evidences of climate change from wet to dry conditions

The records of floods diminished significantly since the foundation of the Xia Dynasty. The Yellow River was also kept quiet. The first change in the course of Yellow River since Yu was found in the 7th century BC about more than one thousand years later. It showed the role of regulation by Yu. However, some one said that the development of droughts might also take part in mitigating the impact of floods. No historical records of the droughts in the time are available. Therefore, we will rely only upon palaeo-climatic and palaeo-environmental evidences to investigate the climate change from wet to dry events around the foundation of the Xia Dynasty.

Fang *et al*.[10] demonstrated the climate change from wet to the dry conditions in 3.7−3.5 ka BP in northern China. It relates to about 2100−1800 BC of calendar years. The assorted data are outlined as follows:

(1) Pollen data in Daqingshan near Hohhot of Inner Mongolia showed that annual mean tempeature in 6.7 ka BP was 2−3℃ higher and annual precipitation was 100 mm greater than that at present. Content of woody plant pollen reduced to 50% in 3.7−3.5 ka BP.

(2) Content of water algae abruptly decreased, while plants of sedge family luxuriated in Diaojiaohaizi in 3.7−3.5 ka BP. It means that the amount of water was reduced in the lakes.

(3) Daihai Lake near Hohhot of Inner Mongolia is fed by the precipitation, so the level of Lake manifests the variations of precipitation. It shows that precipitation was high before 4.0 ka BP.

(4) Magnetic susceptibility of old soils in Yulin near the Mu Us Desert was 30 and 40 in 4.80 ka BP and 4.35 ka BP, respectively. However, it reduced to no more than 10−15 after 3.5 ka BP. It infers that the climate turned to dry and cold. Similar change was also found in Horqin sandy land of the east part of Inner Mongolia.

(5) Qinghai Lake, the greatest inland lake in China, is located in the northern border of the converging zone of the southeast and southwest monsoons. Pollen of tree was predominated over 7.6−3.5 ka BP, while the Lake's biomass increased, and salinity decreased. It means that precipitation was high in that time and summer monsoons were strong. However, pollen of trees decreased, organic carbon also decreased, but content of carbonate increased in 3.5 ka BP. It showed decrease in precipitation. Temperature and precipitation series reconstructed using the pollen data in Qinghai Lake indicated the 20% lowering of precipitation in 3.5 ka BP comparing to that in 4.0 ka BP [6].

(6) Pollen data in Yanggao, Shanxi showed a total content of pollen of 70%−80% in 6.0−5.0 ka BP, but it reduced to 40% in ca. 4.0 ka BP. It characterized the climate change towards the cold-dry type.

(7) Archaeological evidences indicated a change from agriculture culture to animal husbandry culture in 4.2−3.5 ka BP (calendar years) in Erdos, Inner Mongolia. No farm tools were found in the archaeological ruins in Chifeng, Inner Mongolia in 4.0−3.5 ka BP (calendar years), but the amount of bone of cow, sheep, and horse increased. The northern border of agriculture retreated to the south by 1° latitude in 4.2−4.0 ka BP (calendar years) in Hulu river basin, Gansu Province. Sheep husbandry developed in Qijia culture. All of the evidences showed a climate change to the dry conditions.

Aforementioned records indicated a reduction of precipitation in 2100−1800 BC from Qinghai via Gansu, Shanxi to the east of Inner Mongolia.

5 Conclusions

(1) Historical, archaeological, palaeo-climatic and palaeo-environmental evidences showed that there was a period with predominance of floods in the late third millennium BC. "Regulation of floods by Great Yu" characterized the ending of the period of floods.

(2) Palaeo-climatic records indicated the abrupt change of climate from wet to dry conditions in 2100−1800 BC (3.7−3.5 ka BP, ^{14}C years) in the northern China from Qinghai via Gansu, Shanxi to the east of Inner Mongolia.

(3) The abrupt climate change to dry conditions in 2100−1800 BC accompanied alternations of archaeological cultures. Accordance was found between historical documentations, archeological records and palaeo-climatic and palaeo-environmental data.

(4) It infers that development of ancient civilization closely related to the abrupt climate change. However, the latter seems not to be the unique factor which controls the evolution of ancient civilization.

Acknowledgements

The author offers sincere thanks to Prof. Fang Xiuqi for the valuable discussion.

References

[1] Expert Group. Technology of Chronology of Xia, Shang and Zhou Dynasties, 1996−2000 [M]. Beijing: World Books Press, 2000 (in Chinese).

[2] Zhou Heng. The birth of Chinese civilization [C]// Zhou Heng. Proceedings of Archaeology of Xia, Shang and Zhou Dynasties (Vol.2). Beijing: China Science Press, 1998: 89−94 (in Chinese).

[3] Jiang Linchang. New Probe of Civilization of Xia, Shang and Zhou Dynasties[M]. Hangzhou: Zheijiang People's Press, 2001: 14−47 (in Chinese).

[4] Su Bingqi. General History of China (Vol.2): Far Ancient Age [M]. Shanghai: Shanghai People's Press, 1994: 45−47 (in Chinese).

[5] Wang Shouchun. Archaeological culture and literature record on the climate and environment changes along the Yellow River Valley[C]// Shi Yafeng. Climate and Environment during the Megathermal of the Holocene in China. Beijing: China Ocean Press, 1992: 175−184 (in Chinese).

[6] Shi Yafeng, Kong Zhaochen, Wang Sumin, *et al*. Fundamental characters of climate and environment in the Megathermal of the Holocene in China [C]// Shi Yafeng. Climate and Environment During the Megathermal of the Holocene in China. Beijing: China Ocean Press, 1992: 1−18 (in Chinese).

[7] Shi Shaohua. Environment of Megathermal in the Holocene of China and development of ancient civilization in Neolithic Age [C]// Shi Yafeng. Climate and Environment During the Megathermal of the Holocene in China. Beijing: China Ocean Press, 1992: 185−191 (in Chinese).

[8] Xu Xusheng. The Legend Period of Ancient History in China [M]. Guilin: Guangxi Normal University Press, 2003: 148−189 (in Chinese).

[9] Xia Zhengkai, Yang Xiaoyan. Preliminary study on the flood events about 4 ka BP in the northern China [J]. Quaternary Sciences, 2003, 23(6): 667−674 (in Chinese).

[10] Fang Xiuqi, Zhang Lansheng. Research on the abrupt change events of precipitation around 3500 a BP in the farming-grazing transitional zone of the northern China [J]. Journal of Beijing Normal University (Natural Science), 1998, 34 (Suppl.): 18−23 (in Chinese).