REVIEW ARTICLES

Some problems on the studies of the late Pleistocene human evolution and formation of modern human populations*

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Abstract For the past two decades, studies and debates on the modern human origins around the world have attracted attentions to the late Pleistocene human evolution and formation of modern human populations, and some controversial hypotheses and problems have been proposed. In the present paper, some problems on the late Pleistocene human evolution, and the formation and differentiations of modern human populations in China are studied with a brief description and comments on the research advances in this field.

Keywords: late Pleistocene, human evolution, formation and differentiation of modern human population, paleoanthropology.

According to the evidence from human fossils, in late Pleistocene humans evolved into the stage of late *Homo sapiens* with their morphologies resembling those of living humans. So the humans in late Pleistocene are called anatomically modern humans. Starting from late Pleistocene, human began to migrate to the wide graphic areas around the world, including Africa, Asia, Europe, America, Australia and Pacific islands. During this course humans gradually differentiated into different races or regional populations. The studies of human fossils, chronology, behavior, cultural development and environments for late Pleistocene humans are of great importance to explore different aspects related to the origins and dispersals of modern humans, origins of modern races, and also the occurrence of early civilizations. Recent studies in this field point out some new problems for the human evolution in late Pleistocene, and some traditional opinions are challenged[1—3]. In the present paper, I will give a brief description and comments on the research advances in this field, then discuss some problems on the late Pleistocene human evolution, and the formation and differentiations of modern human populations in China with recent studies carried out by Chinese colleagues.

1 Some problems and thinkings caused by the studies and debates on modern human origins

In the past 20 years debates on modern human origins have received significant attention in paleoanthropological research. The two opposite hypotheses "Out of Africa" and "Multiregional evolution" are in the center of this debate[4—6]. The modern human origin in China and the whole East Asia is an important issue in this debate, and the hypothesis "Regional continuity with hybridization" for human evolution in China has served as the core of the hypothesis "Multiregional evolution"[7]. Among the various kinds of materials for the research of modern human origins, late Pleistocene human fossils and the associated remains are most important. With the advances in the related studies, the information for the late Pleistocene human evolution, and formation and differentiations of modern human populations has rapidly accumulated, and a series of new problems have been proposed.

1.1 Time of the formation and differentiation of modern human populations

Modern humans are classified as different popu-

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lations or races according to their physical characteristics and geographic distributions. The traditional opinion holds that in the later period of late Pleistocene (about 30 kyr B.P.) or even earlier, humans possessed the morphological features characterizing the modern populations or ethnic groups (races), so the modern ethnicity may form in this time period. However, such an opinion has been challenged in recent years. The evolution of human physical characteristics during the period from late Pleistocene to Holocene includes two aspects. On the one hand, most features approached those of modern humans and some remained primitive features disappeared gradually. This process is called modernization. On the other hand, the modern populations or ethnic groups began to form, which are characterized by the population differentiations and morphological diversifications. For this reason, the studies of late Pleistocene human evolution and formation of modern human populations include two aspects: (1) the occurring time of modern human and modern human features; (2) formation time of morphological features of modern human populations or ethnic groups. Recently, based on comparative studies of late Pleistocene human fossils, and recent and modern human skeletal collections from around the world, some people proposed that the morphological features for some specific modern human populations or ethnic groups formed very recently, or formed in the humans already belonging to modern human types[1, 2]. According to such an opinion, modern human populations or ethnic groups formed in Holocene.

1.2 The morphological features characterizing modern populations or ethnic groups

For many years, research on the late Pleistocene human evolution, origins of modern ethnic groups and population affinities depends mainly on the identification of some morphological features characterizing some specific ethnic groups or populations. However, in recent years, more and more colleagues raised questions for the reliability of the morphological features widely used for ethnic identification. Some skeletal and dental features, which were regarded as characterizing some populations or ethnic groups, have been found to be not fit with the corresponding populations, but have higher occurrences or pronounced expressions in the populations of other geographic regions[1, 2, 8, 9]. The studies of the present author in recent years also got the similar findings[3]. Various reasons might be responsible for such a phenomenon, including misunderstanding the morphological features of ethnic groups, and also the migration and admixture of the populations in the past 10 kyr. Besides, many colleagues including myself have realized that some skeletal and dental features, especially some nonmtric features used in the anthropological research lack universal definition and scoring standards. The definitions of some features are even not precise. The existence of this problem reduces the reliability and accuracy of the data collected by different people and makes the comparisons of data from different studies difficult.

1.3 The factors influencing the expressions of morphological features

The prerequisite for the study and comparisons of physical characteristics to explore the formation, migration and affinities of human populations is confirmation of genetic inheritance of these features. However, limited by the current level of research and understanding, detailed mechanisms for the numerous physical characteristics including their formation, expression, function and variations are not clear. However, at least we are sure that environmental factors greatly affect the expressions of some features or the changes of these features are a kind of functional adaptations. Moreover, the values of such features are very limited for population affinity research because the expressions of some other features are affected by both genetic and environmental factors, which further increases the complexity using these features for population affinity studies. For example, mandible torus (bony prominence on the inferior surface of mandible) has been regarded as the Mongoloid features, but some recent studies indicate that the occurrence and expression of this feature are closely related to the development of muscles and mastication functions, which actually reflects adaptations to function and environment[10, 11]. Our studies of skeletal collections from archaeological sites found that mandibular torus has higher frequencies in the populations with their main life styles as hunter in Xinjiang and Inner Mongolia than those agricultural populations from central plain areas along the Yellow River[12].

2 Late Pleistocene human evolution and formation of modern human populations in China

For the past decade, the origin and differentia-

tions of modern human populations in East Asia have received great attention in paleoanthropological research[13, 14]. The Mongoloids are usually referred to as the modern human populations living in East Asia and the local populations in America. Among them, populations living in Northeast Asia including China, Mongolia, Korea and Japan are called typical Mongoloids, and the people living in Southeast Asia are classified as southern Mongoloids. With rich paleoanthropological resources including human remains ranging from late Pleistocene to Holocene Neolithic period, China has advantages to study the formation and differentiations of modern human populations in East Asia. The present author believes that even though many studies have been carried out in this field by Chinese colleagues, the problems restricting the research of the formation and differentiations of modern human populations mentioned above still have influences on the research of late Pleistocene human evolution and formation of modern human populations in China. These influences are reflected in the following aspects.

2.1 The evolutionary status of the humans of Upper Cave and Liujiang

The human cranium and postcranial remains found at the sites of Upper Cave and Liujiang are the most complete and well preserved late Pleistocene human fossils ever found in China. For decades, the Upper Cave and Liujiang human fossils have been in an important position in the research of origins of modern Mongoloids. The original studies indicate that although some primitive features shared by late Pleistocene humans still can be identified, both Upper Cave and Liujiang fossils already have many modern Mongoloid features. They have been regarded as an early type of on-forming Mongoloids named archaic Mongoloids, proto Mongoloids and primitive Mongoloids[15, 16]. In the past 20 years, a series of further studies have been carried out on the Upper Cave crania addressing their morphology, evolutionary status and the role in the origin of modern Mongoloids[17—19]. In these studies, some colleagues proposed that the variations within the Upper Cave crania exhibit more significant variations than the individuals within more recent human populations. Furthermore, the Upper Cave fossils never fall into the same modern human population. The Upper Cave fossils may represent the members of the generalized population living in the late Pleistocene. Besides, some people pointed out that the so called modern Mongoloid features on the Upper Cave specimens are of no diagnostic value and really did not occur[20, 21]. The human cranium and postcranial remains found in Liujiang in 1958 are the most complete and well preserved late Pleistocene human fossils ever found in south China. Since the discovery, only one detailed morphological description has been made by Woo[16]. He believed that the Liujiang fossils preserve some primitive features of late Pleistocene humans but a group of modern Mongoloid features can also be identified. So, he put Liujiang as an early type of on-forming Mongoloids. For the past decades, great advances have been achieved in the paleoanthropological research with deeper understandings of the morphological pattern, evolutionary change, geographical variation, mechanism and possible environmental influences. With such a background, previous studies on the Liujiang fossils are far from the current needs. Therefore, I propose that the following problems related to the Liujiang human fossils should be solved: (1) Do the morphological expression patterns of Liujiang fossils fit with its dating of 67 kyr BP or even earlier ages[22]? (2) Compared with the modern East Asian populations, to what extent do Liujiang fossils have the modern human features? How many primitive features do the Liujiang fossils still preserve? (3) How different morphologically are the Liujiang fossils with those of the Upper Cave? Do some evolutionary links exist between the Liujiang and modern southern Mongoloid population?

2.2 The formation and differentiations of modern human populations in China

There are significant differences of the physical characteristics for the people living in different parts around the world. The modern human populations are usually classified as race or ethnic groups according to their physical characteristics. Many colleagues incline not to use the term race, instead, different populations are named mainly according to their geographic distributions. For modern human populations in China, a series of studies of skeletal collections, anthropometric analysis of living populations and genetic studies indicate that the physical characteristics of modern Chinese populations can be divided into south type and north type bordering along the Yangtze River. This south-north division might form during the Neolithic period[23—25]. Some colleagues even proposed that the Mongoloid features of modern Chinese formed as early as 100 kyr BP. The Mongoloid features fully formed in the late Pleistocene hu-

mans in China, and south-north division also occurred in this period. The differences of cranial morphology between Upper Cave and Liujiang indicate that they represent two regional types in north and south China respectively. They might be the direct ancestors of modern southern and northern Mongoloids respectively[26,27]. However, details about the problems mentioned above were not touched in all these studies. The present author proposes that in the near future, the following academic questions related to the late Pleistocene human evolution and formation of modern human populations in China should be solved through research: (1) To what extent do late Pleistocene humans in China like Upper Cave and Liujiang possess the shared common morphological features of modern Chinese populations or modern Mongoloid features? (2) Compared with modern Chinese, how many primitive features do the late Pleistocene humans in China still preserve? (3) What physical characteristics, which can be used as ethnic or populations identification, do modern Chinese populations possess? (4) Mainly based on the studies of skeletal collections from archaeological sites in China, some colleagues classified the humans living in Neolithic through historical periods into several subtypes of Mongoloids. How much reliable are the determinations of these ethnic types? What roles do these ancient ethnic groups play in the origin and differentiations of modern Chinese populations?

2.3 Is there any influence from Europe for human evolution in China?

During the human evolution and formation of modern human populations in China, is there any influence from other places around the world? To what extent is the influence? All these questions have attracted the attentions of paleoanthropological researchers in China. According to the studies conducted in the past decades, some colleagues believe that there were gene flows from Europe during different time periods of human evolution in China. For example, based on the studies of human fossils, some colleagues proposed that the highly projecting nasal bones of *Homo erectus* from Nanjing, and the occipital bunning observed on the crania of Lijiang, Ziyang and Lijiang are the evidence of gene flows between China and Europe[7,28]. According to these studies, Wu Xinzhi proposed his hypothesis "Continuity with hybridization" which explains the evolution from *Homo erectus* to late *Homo sapiens* in China as a main course of continuity with some genetic influences from other parts around the world. However, there are different opinions for this hypothesis even from Chinese colleagues[3,29]. The main debates focus on the different understandings of two points: (1) Are these morphological features really characteristics of humans in Europe during some specific time period; (2) What is the mechanism for the formation of these features? Currently, there are different opinions for the entrance time of genetic influences into China from Europe. According to the evidence from archaeological studies and natural geography, some colleagues proposed that the genetic influence from Europe entered China after Holocene, most possibly through the northwest China, especially Xinjiang neighboring the central Asia[30,31]. So far, many bronze age human remains have been found in that area. Preliminary studies indicate that morphological features of human bones found in Xinjiang resemble those of Europeans, and differ from those of the humans of the central plain along the Yellow River. Therefore, it is not possible for the *Homo erectus* from Nanjing to have the affinities with European humans. For the question that if the physical characteristics of late Pleistocene humans of China had European influence, more reliable evidences are needed to demonstrate this issue.

3 Some recent studies carried out by Chinese colleagues

Since 2000, the colleagues affiliated with different institutions, including Institute of Vertebrate Paleontology and Paleoanthropology, CAS, have carried out a series of studies in the field of late Pleistocene human evolution, and the formation and differentiations of modern human populations in China. These studies focus mainly on the following aspects.

3.1 Late Pleistocene human fossil sites newly found in China

Among the various research materials for modern human origins, the late Pleistocene human fossils and related remains are most important. For some specific geographic regions, finding earlier aged late Pleistocene human fossils will provide key evidence to determine the time of modern human origin in this region. Several anatomically modern human fossils dated 100 kyr BP or earlier found in Africa have been used as the key evidence to support the "Out of Africa" hypothesis[32,33].

The age of most late Pleistocene human fossils so far found in China is younger than 50 kyr BP. Even though some fossils are claimed to be older than this age, the ages are not widely accepted or are still being debated[22]. So there is still a big human fossil gap between 50 and 100 kyr BP. For the past five years, more efforts have been made to look for the human fossils in this time period, which resulted in the discoveries of some new late Pleistocene human fossil sites. Among them the Tianyuan Cave near Zhoukoudian, and a series of sties in Western Hubei and Three Gorge regions are included.

The two excavations at Tianyuan Cave in 2003 and 2004 unearthed human and many mammal fossils. The human fossils are composed of 34 specimens, including a mandible, teeth, and post-cranial bones. Preliminary analyses indicate that the fauna composition of the Tianyuan Cave stays between the Upper Cave and the living fauna, but more closer to that of the Upper Cave. The results of absolute dating by several methods gave the age of 25.3 kyr BP, approximately the same age as that of Upper Cave[34].

Besides, several late Pleistocene human fossil sites recently found in the Western Hubei and Three Gorges regions are especially important (Fig. 1). The Western Hubei and Three Gorges are referred to as a narrow area across the western part of Hubei Province with the Three Gorges regions intermediate. Since the first discovery of human maxilla fragment in Changyang in 1957, at least 10 human fossil sites have been found in this region. Except for the human

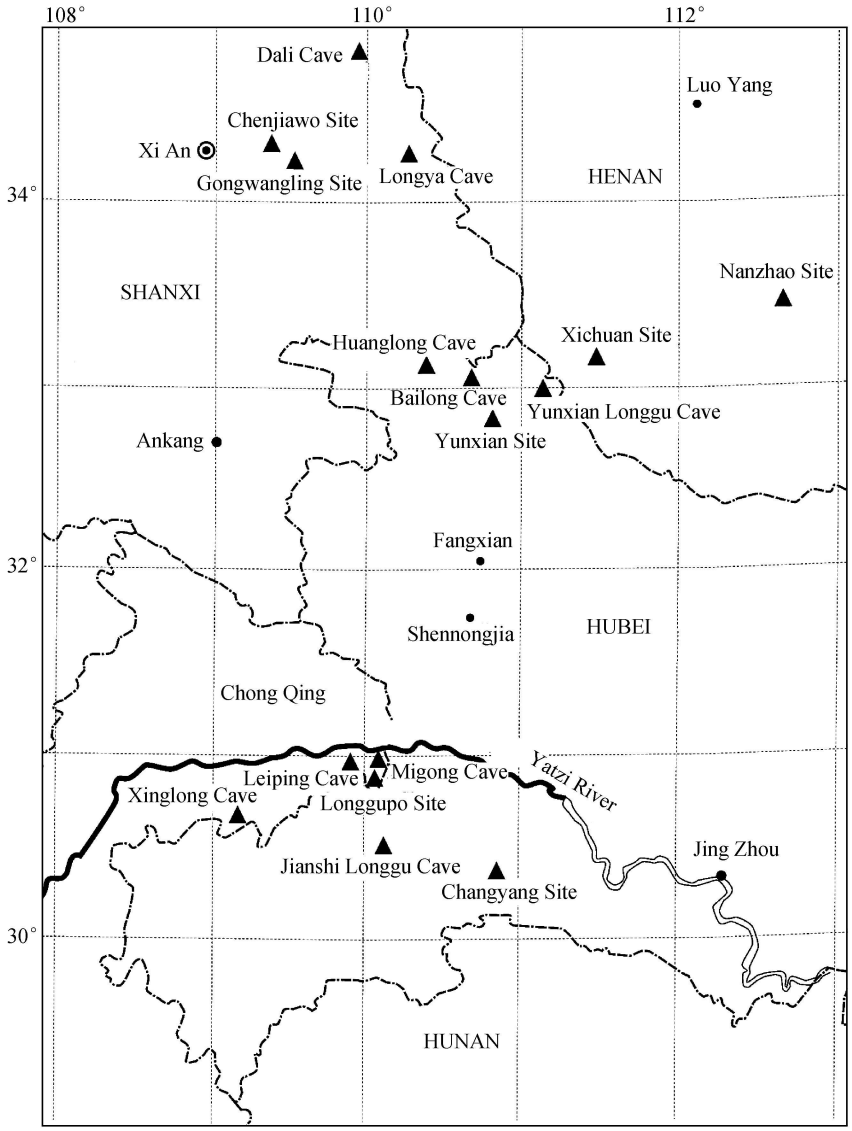

Fig. 1. Human fossil sites in and around West Hubei and Three Gorges regions.

fossil sites, more than 30 sites with stone artifacts and other evidence showing human activities have also been located. Since 2000, our field surveys have found 4 new late Pleistocene human fossil sites. Among them, Xinglong Cave in Fengjie County, Chongqing City and Huanglong Cave in Yunxi County, Hubei Province are most important[35, 36]. The excavations through 2002 to 2004 at Xinglong Cave unearthed four human teeth, some stone artifacts, ivory engravings and other cultural remains. In 2004, our test excavation at the Huanglong Cave found 5 human teeth, 20 stone tools and nearly 2000 mammal fossils. Preliminary analysis and dating (U-series and ESR) indicate that the age of the human teeth is around 103—94 kyr BP (Fig. 2).

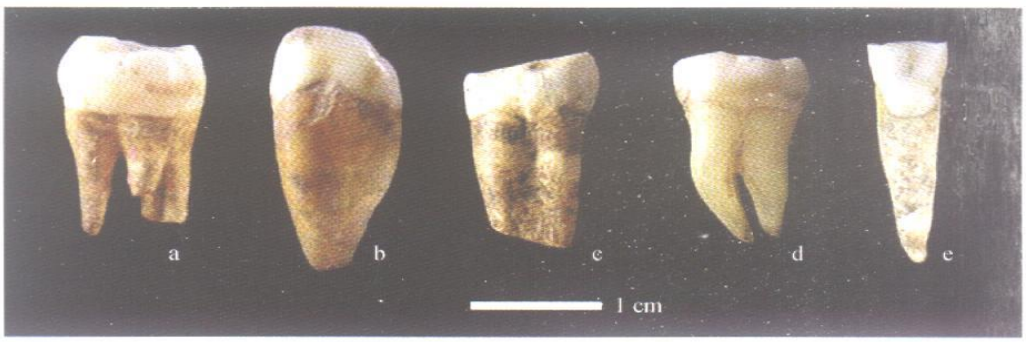

Fig. 2. Human teeth found at Huanglong Cave, a late Pleistocene human fossil site in Yunxi County, Hubei Province.

All these discoveries provide new materials with important information for research on the late Pleistocene human evolution and modern human origins in China. More importantly, the ages of Huanglong Cave and Xinglong Cave are in the ranges between 100 and 50 kyr BP, which are valuable for demonstrations of some debated issues.

3.2 Studies on the cranial morphology and evolution of Upper Cave and Liujiang

Because great attention has been paid to the evolutionary status of Upper Cave and Liujiang, we carried out some comparative analyses of cranial morphology between the Upper Cave and Liujiang, and also between each of them and modern Chinese specimens, which include more than 1000 individuals from different parts of China[37, 38]. Our results show that: (1) The expressions of most morphological features on Liujiang cranium are within the variation ranges of modern Chinese, and only small numbers of features on Liujiang cranium have different expressions from modern Chinese; (2) a few primitive features like lower orbit can be observed on Liujiang cranium, indicating that the Liujiang cranium still preserves some late Pleistocene human features, but compared with other late Pleistocene humans especially Upper Cave, the Liujiang cranium is much more modern; (3) the morphological differences between Liujiang and Upper Cave are mainly expressed as more primitive and robust features occurring on the Upper Cave than Liujiang. A few features showing the differences may be related to the climate or environmental adaptations, which include the deeply depressed nasion of Upper Cave and broad nose of Liujiang. Based on these findings, we believe that the cranial morphology of Liujiang is very close to those of modern Chinese and very few differences exist between them. Our studies do not support the opinion that the Liujiang cranium is more primitive than those of Upper Cave and Ziyang, and even put Liujiang as the earliest late Pleistocene human in East Asia. The cranial differences between Liujiang and Upper Cave mainly reflect their evolution, and to a less extent the influences from the living environments. Considering the similarity of cranial morphology between Liujiang and modern Chinese, and the uncertainty of the fossils yielding layer of Liujiang, we believe the current morphological evidence does not support the earlier age for Liujiang human fossils[22].

3.3 The physical characteristics of recent and modern populations in China after Holocene

It is generally accepted that the differentiations of modern human populations occurred in Holocene within 10 kyr. In the past decades, abundant amounts of human remains including bones and teeth have unearthed from numerous archaeological sites in China with ages ranging from the early Neolithic about 7 kyr BP to historic periods, and with their geographical distributions from frontier to inland areas. These collections contain valuable information about the biological features of different human populations

of Holocene in China. To some extent the information reflects the behavior and living environments of the populations. In recent years, a series of studies on the skeletal and dental morphology, and their temporal changes of the Holocene human populations in China have been carried out. These studies address mainly the following issues: (1) the cranial morphology of Holocene human populations in China and its variations during the formations of modern human populations; (2) the comparisons of cranial features between Chinese and African Holocene humans; (3) ancient DNA studies.

The main findings from these studies reveal that there are significant differences of cranial morphology between different populations in China within the past 10 kyr. These differences are most obvious between the populations living in the central plain areas and different populations from the frontier areas of northwest, Inner Mongolia and northeast. There are also differences for the expressions of some morphological features between the populations living in north and south China. Besides, many morphological features are not only controlled genetically but influenced by environments and function adaptations. The comparisons of cranial features between recent and modern human populations living in Africa and China indicate that African populations possess some specific features, but the expressions of most morphological features resemble those of Asian populations, which suggests the homogeneity of morphology in living populations around the world. The more diversities observed on the skulls of African populations than that of Chinese populations indicate that the modern African populations have wider variations in physical characteristics than Asian populations. These studies are of great value to explore the formation and differentiations of modern human populations in China, and the possible influences from other parts of the world including Europe. In the field of extraction and analysis of ancient DNA of human remains from archaeological sites, especially for the studies of population affinities, migrations, admixtures of some ancient populations living in northwest China, great progress has been achieved. Some new opinions have also been proposed[39—42].

4 Future research

Recent advances in the research of late Pleistocene human evolution and formation of modern human populations in China are mainly reflected by the more clear understanding of some key problems to be solved in this field. At the same time, a series of effective studies have been conducted in some aspects of the field including some new late Pleistocene human fossil sites in the Western Hubei and Three Gorges regions, studies of the cranial morphology and evolution on Upper Cave and Liujiang. All the progress has promoted the research of modern human origins in China. The present author believes that more attention should be paid to the following issues to achieve further progress.

4.1 Looking for more complete late Pleistocene human fossils

As mentioned above, till now, the ages of most late Pleistocene human fossils found in China are within 50 kyr BP. Even though some fossils are claimed earlier than 50 kyr BP, nearly all their ages are in debates. In recent years, a few human fossils earlier than 50 kyr BP were discovered, but they are mainly isolated teeth or fragmentary bones. Because the information attracted from these fossils is limited, more efforts should be made to look for the more complete human fossils in the time ranges of 100—50 kyr BP.

4.2 Strengthening the coordination with the genetic studies

In the research field of late Pleistocene human evolution and formation of modern human populations, except for the fossil evidence, the studies of paleolithic archaeology, genetics, paleontology, geology and chronology are also very important. It is especially noteworthy that the genetic studies are playing more and more important roles. Recently, based on the genetic evidence, some colleagues proposed new opinions on the modern human origin and formation of modern human populations in China[43—46], which caused debates among the colleagues, especially from the paleoanthropologists[47]. Although human fossils are more informative and give direct evidence for the research of human origin and evolution, in many cases, it is not easy to find complete human fossils. In such a situation, the studies in some related disciplines including genetics can also play important roles. In fact, many genetic studies have been carried out in the field of late Pleistocene human evolution, and the formation and differentiations of modern human populations in China with some noteworthy opinions have been proposed. The present author be-

lieves that currently the coordination and communications between the paleoanthropological studies and genetics studies in this field are not enough, which to some extent impedes the colleagues from the paleoanthropology and genetics to accurately obtain, use and analyze the related data, and finally give more reasonable explanations. The present author thinks multidisciplinary research including paleoanthropology and genetics in future will be an important channel to produce high level academic achievements in this field.

4.3 Expanding the research area and methods

Because human evolution experienced long time periods with influences of different environments, the available human fossils are very rare. So all the human fossils are direct evidence to study human evolution. In recent years, some new methods have been used in paleoanthropological studies, which has played very important roles in further extracting the useful information about human fossils. So far, rich late Pleistocene human fossils have been found in China. Among them some complete or relatively complete crania are included, like Liujiang, Upper Cave, Ziyang, Lijiang, and Chuandong. However, till now the studies on these human fossils are only limited to the traditional morphological observations and measurements. In future research, the employments of high resolution CT, virtual reconstruction, 3D shape analysis will provide more useful information of the fossils. Besides, some new research field currently not widely carried out in China should be conducted, such as brain evolution by endocasts and diets by dental microwear analysis.

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