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An archaeological perspective on the origins and evolution of modern humans in China

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Abstract: Recent paleoanthropological and Paleolithic archaeological discoveries have drastically altered our theoretical perspectives on modern human origins, evolution and adaptations. China, a vast geographic region in East Asia, has emerged as a hot-spot for such studies. New human fossils and stone tool assemblages have been reported from the area which challenge the "Recent Out-of-Africa" model, based mostly on the African and western Eurasian records. New paleoanthropological research results indicate that early modern humans appeared in South China around 100 kaBP, and might have at least partially evolved from aboriginal populations there. Some archaic *Homo sapiens* exhibit mosaic or transitional features and possible admixture with Neanderthals and Denisovans. Associated lithic industries exhibit the complexity of early modern human technologies and behaviors. While small flake tools in North China and large pebble tools in South China dominated throughout most of the Pleistocene, beginning from ca. 40 kaBP, a large blade techno-complex appeared at some sites in North China, followed by the emergence of bone tools and personal ornaments in the same area slightly later, indicating possible technological ties with lithic industries in Siberia and Central Asia and possible northwest-to-southeast migrations in northeast Asia during the late Upper Pleistocene. Human fossil remains and archaeological evidence cumulatively suggest that the trajectories of modern human origins and adaptations in China might be different from those of western Eurasia. In this paper, we compile new discoveries and outline progress in research on archaeological studies of the origins and evolution of modern humans in China. We adopt a predominantly archaeological perspective on these critical academic issues, and offer several suggestions for future studies.

Keywords: China; origins and evolution of modern humans; behavioral modernity and complexity; continuity with hybridization

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1. Introduction

For more than three decades, the origins and evolution of modern humans have been the most important and broadly inclusive issue in paleoanthropological research worldwide and one of the major points of attention of popular media as well. Discussions and debates on these topics have long been focused on two competing theoretical models, the "Recent Out-of-Africa"(also known as Single-Place Origin or Total Replacement) hypothesis and the "Multiregional Evolution" paradigm[1-7]. Recently, as more fossil, genetic and cultural evidence has accumulated, it has become clear that the origin and evolution of modern humans was an exceedingly complicated process, in which some archaic hominin groups, such as the Neanderthals and Denisovans, thought to have been completely extinct and essentially irrelevant to our species, were found to have contributed certain specific and identifiable genetic material to our gene pool[8-11], and that interbreeding played a very important role in the emergence of early modern humans. As a result, models of the origins of modern humans have been revised accordingly, and the so-called Assimilation Model has generated increasing interest and support[12-14].

From an archaeological perspective, modern behavior documented in material culture appeared in various regions at different times which are not always synchronous with the fossil and genetic records. Thus, behavioral modernity is not exclusively associated with anatomically modern humans; consequently, some scholars have shifted their research focus toward behavioral variability[15].

Recently, great progress has been made in China at the interface of paleoanthropology, archaeology and molecular biology. While mainstream Chinese geneticists still insist that the modern Chinese population descended directly from originally African immigrants who arrived in South China about 50 kaBP, fossil evidence has demonstrates that archaic to modern human evolution in China was a continuous and, most importantly, mosaic process: certain modern human morphological characteristics appeared quite early, documented by hominin fossils dating to the late Middle Pleistocene and early Late Pleistocene[16,17]. Fossil hominins with fully modern *H. sapiens* morphology were living in south and central China as early as ca. 100 kaBP[18-20].

The DNA sequences reconstructed for an early modern human from Tianyuan Cave, near Beijing in North China, revealed that this individual derived from a population that was ancestral to many present-day Asians and Native Americans but postdated the divergence of Asians from Europeans[21]. Evidence from Paleolithic archaeology also indicates a continuous development of lithic technology in China and greater East Asia since the Early Paleolithic. No obvious gap existed from 100~50 kaBP, as has been proposed by some geneticists examining the Chinese fossil and archaeological records in support of the "Out-of-Africa" hypothesis[22,23], which implies that no total population replacement occurred during this period in China[24]. These new

discoveries and research advances, especially achievements gained through interdisciplinary and, increasingly, transdisciplinary studies, have made the origins and evolution of modern humans in the region much clearer as more details are revealed[14]. However, controversies regarding models of modern human origins and some missing links in fossil and genetic evidence remain, recognizing also that varying interpretations of the same body of evidence sometime occurs.

2. Archaeological evidence for regional continuity of human evolution in China

Archaeologists in China were largely silent early in the debate over modern human origins. As an evolutionary gap in China between roughly 100–50 kaBP was proposed by geneticists to support a population replacement model, some paleoanthropologists began to seek evidence from the Paleolithic archaeological record to invalidate such a claim[25,26]. As a result, some archaeologists joined and began to contribute to this lively, not to say contentious, discussion[7,14,24].

Following his systematic synthesis of Pleistocene cultural remains collected in China, Gao[24] noted that the development of Paleolithic industries there occurred in one uninterrupted trajectory, indicating that Pleistocene hominins survived and evolved continuously in the region. Through the study of the emergence of so-called "Western cultural elements" such as Levalloisian products, Acheulean-like assemblages, and blade tools in the Chinese Paleolithic, it is apparent such elements never defined the mainstream of stone tool production, let alone replaced local technocomplexes, but, rather, were probably assimilated into the extant local material culture. Such evidence has provided archaeological support for the evolutionary continuity of Pleistocene hominins in China and the Continuity with Hybridization hypothesis instead of the "Recent Out-of-Africa" model. The hypothetical occupation hiatus in China between 100~50 kaBP proposed by molecular biologists has been invalidated through archaeological research because some sites have now been dated to within this temporal window as a result of improved chronometric techniques, especially the Optically Stimulated Luminescence(OSL) method. Moreover, paleoenvironmental reconstruction in China demonstrates that the region was not as harsh as what supporters of the "Recent Out-of-Africa" model have suggested, especially in central and southern China.

Numerous archaeological materials unearthed from the Shuidonggou(SDG) site-complex in Ningxia provide a large body of information to fuel discussions of cultural continuity, behavioral modernity and variability, and the influence of in-migrated populations in certain areas. The Shuidonggou site-complex is located on the southwestern edge of the Ordos Desert, 28 km southeast of Yinchuan city and 10 km east of the Yellow River. Here, a total of 12 localities bearing late Pleistocene archaeological materials buried in sandy silt deposits have been discovered and investigated. Since 2003, renewed multidisciplinary research has been carried out at various SDG localities. This cumulative body of research has demonstrated that human groups

utilized the SDG area over a much longer time range than was previously suspected, employing complex but successful behavioral and technological strategies[27-29].

This aggregated information yields a complex story of the adaptation, migration, cultural exchange, and technological evolution of hominins in East Asia since ca. 40 kaBP[27,29]. Beginning roughly 45-40 kaBP, blade technology with Levallois features(the Initial Upper Paleolithic industry, or IUP) emerged in this area, unearthed from the lower cultural horizon of SDG 1, 2 and 9. Technological comparisons with similar finds in Siberia and Central Asia indicate population dispersals from the west or north of the site[30-32]. However, this techno-complex did not persist in the area, played little role in shaping the local lithic technology, and was eventually replaced by a local core-flake technology[30,31].

Most of these core-flake tools were unearthed from the middle and upper horizons of SDG 2, overlying the IUP cultural layer and appeared around 33 kaBP and, persisting until ca. 27 kaBP in the region. Lithic assemblages during this period show consistent technological and morphological features, including comparatively simple flake production and side-scraper-dominated tool assemblages. These core and flake assemblages contain no evidence of the systematic production of blades or Levallois elements. However, some technological changes and innovations are evident from the sequence of core-flake reduction[29]. For instance, in addition to stone tools manufactured from river pebbles, some artifacts made of high quality chert with unrolled cortex were also discovered in Archaeological Layer 2(AL2). Investigations in the area show that pebble raw materials are easily found on riverbanks and old terrace gravel deposits near the site, but fine chert cannot be sourced near the site; such materials must have come from a primary source at some distance away from the site, and soft-hammer percussion might have been used for the reduction of this latter material. Finely retouched end-scrapers, made mainly on flake blanks, are present in assemblages from the top cultural levels(AL 1 and 2) but not in earlier strata. These features demonstrate a clear trajectory of continuous development and the refinement of longstanding core-flake industries in the region.

In addition to various lithic technological complexes, the SDG site cluster has yielded abundant additional cultural remains and behavioral evidence including bone tools, ornaments, fireplaces, complex spatial organization, heat treatment of lithic raw material, and plant food gathering and processing[33-38]. Such advanced cultural behaviors, including the manufacture of bone artifacts, systematic use of body decorations, extensive use of earth-pit hearths, distinct functional spatial organization within habitation sites, and extensive exploitation of plant foods, are generally attributed to modern human behavior or behavioral modernity; they provide clues and perspectives for the analysis of early modern human origins and evolution in China and greater East Asia. The emergence of such modern human behavioral evidence within the domain of local core-flake techno-complexes may imply that no replacement occurred in this area. Instead, at least some local populations managed to embark upon and maintain their forward momentum on the evolutionary pathway toward modern humans.

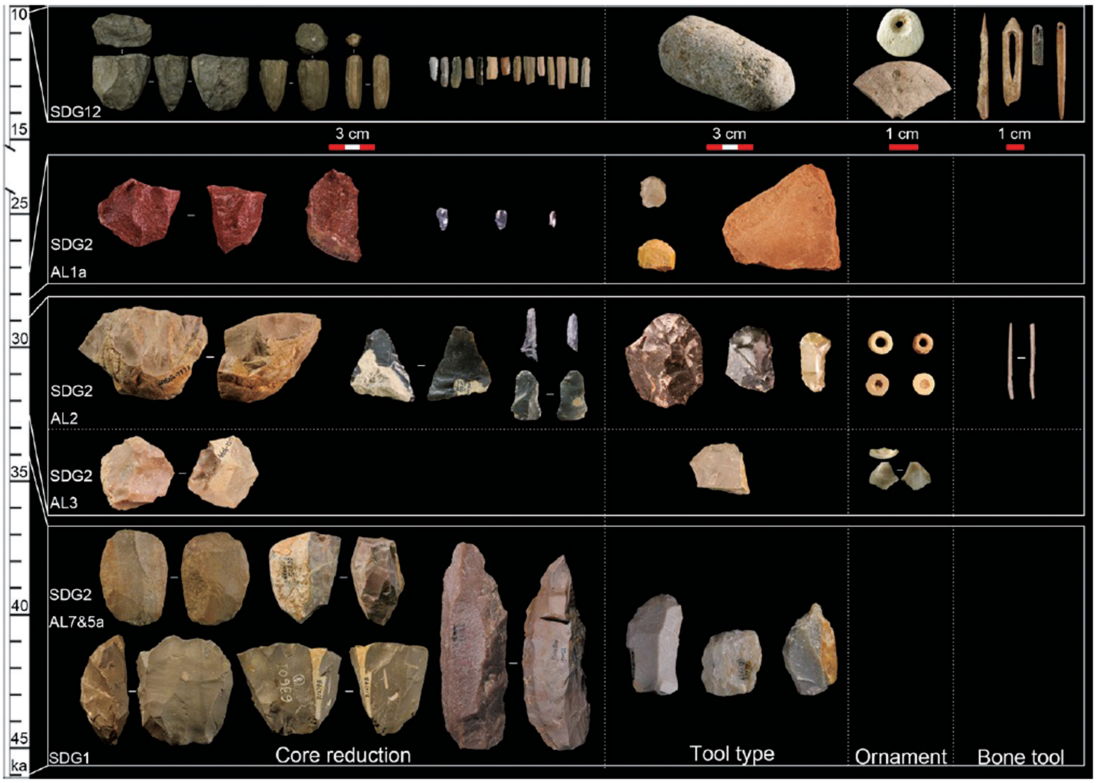

Fig.1 The techno-typological sequence at the Shuidonggou sites[29]

A cluster of newly discovered Paleolithic sites in the Zhengzhou area of Henan province in central China provides additional evidence for regional continuity of cultural development and the emergence of behavioral modernity in China. Sites in this group include Zhijidong, Laonainaimiao, and Zhaozhuang, among others. Rich lithic and faunal materials and hearth remains have been unearthed from these sites dating to ca. 50-35 kaBP. These archaeological remains indicate that human behavior underwent remarkable changes at the beginning of MIS 3, as seen in the long distance transport of raw material and the diversity of toolkits, as well as the enlargement of activity areas. However, the technology of lithic reduction itself did not change much; a simple core-flake technology continued to be used as in the previous period[39].

One special feature worth mentioning here was found at the Zhaozhuang site. Adjacent to a lithic workshop where over 5,000 quartz and quartz sandstone artifacts were discovered, a pile of quartz sandstone blocks was uncovered with an elephant skull on top. When it was recovered, the elephant skull was in a fragmented condition either as a result of post-depositional processes or human activity. Most of these quartz sandstone blocks underlie the elephant skull, but some were also distributed around it. It is believed that the stone pile was purposefully erected to support the elephant skull. These large blocks of purple-red quartz sandstone were extracted and carried to the site from a bedrock outcrop about 5 km distant[40]. It is clear that the transport of these rocks was intended for the construction of the stone “foundation” or plinth rather than the production

of stone artifacts, possibly indicating some kind of ritual activity.

In order to explain the feasibility and dynamics of the continuity of human evolution in China, a Comprehensive Behavioral Model has been proposed[24,41] which has strengthened the argument in favor of aboriginal populations' capacity for survival and evolution into modern humans. This model offers the following observations and explanations for the stable development and unique features of Paleolithic industries in China:

1) *Stable environments and continuity of human evolution.* During the Pleistocene, China was under the influence of a monsoon climatic regime. Studies of the loess depositional sequence and faunal assemblages suggest that even though climatic fluctuations occurred periodically, environmental conditions were relatively stable in the region, and most of the area was suitable for human habitation;

2) *Low-intensity resource exploitation and high mobility.* Most Paleolithic sites found in the region represent seasonal, short-term occupations and associated artifacts that are mostly simple and share basic features of technology, typology and morphology, which may indicate that human groups living in the region maintained a simple and "easy" foraging lifestyle. That is to say they kept their exploitation of natural resources at a rather low level of intensity and seldom felt the pressure to develop innovative new lithic technologies to increase their efficiency or procure more difficult to exploit resources;

3) *Great flexibility in tool technology and adaptation.* The scarcity of high-quality stone raw materials and suitable quarrying sites forced Paleolithic humans living in the area to make best use of poor-quality and locally available raw materials. In dealing with such raw materials exhibiting great variability in lithology and morphology, they learned to be highly flexible and use simple but suitable and effective ways to produce tool blanks and fabricate stone tools. Examples include the bipolar technique that was employed to make use of otherwise intractable quartz nodules that were abundant in the nearby riverbed at Zhoukoudian, and the specialized "Throw and Collision Method" invented to exploit highly polished and rounded river pebbles in the Three Georges Region of the Yangzi River.

Observations and analyses of unique behavioral patterns and social attributes of human beings also provide useful insights into issues such as the nature of geographic isolation on different human groups and the possibility of maintaining a single biological species of human groups living in different regions through time[24]. Archaeology demonstrates that biological isolation of human populations did not necessarily preclude cultural interaction and the sharing and possible convergence of technologies.

3. Evidence for human migrations and interaction in North China

Considering China is a vast area with large topographic and environmental variation, regional continuity cannot comprise the whole story of the origins and evolution of modern humans in China. Migrations and interbreeding must have also played important roles.

In the past, a south-to-north route of early modern human dispersals in China was proposed based principally on genetic studies[42]. The human fossil record from China seems to support this assumption[43] in terms of chronology. For instance, all the known localities yielding the earliest modern human fossils are found in south and central China – sites like Fuyan Cave[19], Luna Cave[44], and Huanglong Cave[18] – all with provisional dates falling between 120~70 kaBP. The earliest known modern human fossils found in North China are from Tianyuan Cave, directly dated to 40 kaBP[45]. A recently revised age for Zhoukoudian Upper Cave(ZKD UC) indicates the modern human remains excavated there minimally date to 35-33 kaBP[46].

However, comparative studies of human fossils from ZKD UC and Tianyuan Cave suggest relations with coeval groups from western Eurasia[45,47]. A recent genetic study found the Tianyuan individual shared alleles with a 35,000-year-old European individual from Belgium[48]. Combining apparent similarities between hominin paleontology and archaeology, Li et al.[46] proposed that the ZKD UC and, probably, Tianyuan modern humans were part of dispersal events across Eurasia following a northern route, as others have suggested[9,49]. Recently, traversable pathways for a northern migration route, eastward toward Siberia and eventually south into northern China, have been proposed[50].

Other evidence potentially indicating modern human dispersal through a northern route comes from the Shuidonggou(Ningxia) and Nwya Devu(Tibet) sites. An assemblage reflecting large blade production was found in the lower cultural horizon of the SDG site-complex[29-31]. This blade techno-complex dating to approximately 35 to 45 kaBP is affiliated with the Initial Upper Paleolithic in eastern Eurasia in that it combined Levallois and prismatic techniques to produce blades. Considering similar and earlier finds that come from localities west of the Shuidonggou area, some scholars have concluded that this techno-complex is intrusive from the Siberian Altai region and/or northern Mongolia[31,32,51]. Interestingly, IUP assemblages lasted for only a short time with an area of distribution limited in China to the northwest and never appeared in eastern North China. Instead, the core and flake technology dominated the Late Paleolithic record there until the emergence of microblade knowhow after roughly 25 kaBP. Based upon the geographical distribution of blade and core-flake industries, Li et al.[31,51] proposed a demographic model of diverse lithic technologies in the late Upper Pleistocene: early UP assemblages indicate human groups dispersed from the west, while core-flake

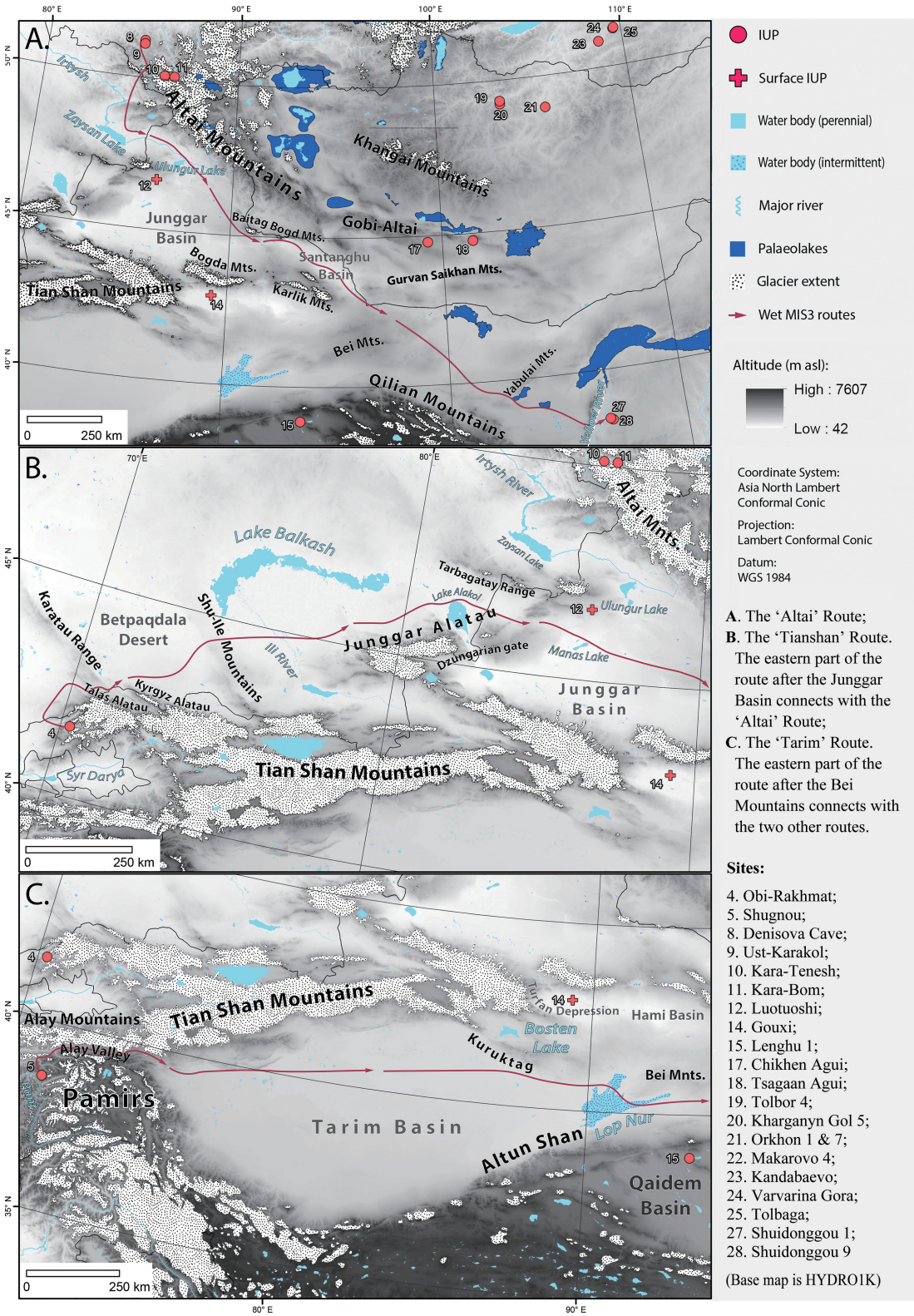

Fig.2 Possible migration routes in Northeast Asia[50]

assemblages imply the continuous evolution of local groups in northern China. The blade assemblage at the Nwya Devu site in Tibet reflects mainly prismatic production of blades, typical of the Upper Paleolithic. Due to the scarcity of this technology in northern China, scholars have linked the blade assemblage at Nwya Devu with similar finds in the Siberian Altai region and Mongolia where prismatic blade production appeared earlier[52].

In addition, population interactions across Eurasia have been inferred based upon the presence of Neandertal DNA in and morphological similarities with the Tianyuan Cave individual[21,45]. Recent finds from Jinsitai Cave, Inner Mongolia[53] and Tongtian Cave, Xinjiang[54] have added additional evidence of Middle Paleolithic(Mousterian) dispersal by means of tracing lithic technology. Mousterian assemblages have been found in these cave sites, including a typical Levallois component and Mousterian-style retouched tools. Classic Mousterian industries are associated with Neanderthal remains at dozens of sites in Europe, the Caucasus, and Central Asia[2,55]. Comparison of the Jinsitai assemblages with those from the most closely adjacent regions, such as the Siberian Altai, suggests that Mousterian assemblages in northern China were probably also made by Neandertals[53]. Complex genetic interactions among modern humans, Neandertals, and Denisovans have been illuminated recently in the Altai region[56-60]. Although determination of the presence of Neandertals in northern China awaits fossil or molecular evidence, the discoveries of Mousterian assemblages and the presence of Neandertal morphological features on some human fossil specimens(such as Lingjing, Henan and Xujiayao, Hebei/Shanxi) indicate a complex picture of Late Pleistocene hominin dispersals and possible physical and technological interactions among different groups in northern China.

4. Bone tools and personal ornaments as expressions of behavioral modernity

Polished bone tools and personal ornaments have been taken as cultural markers of modern humans. Such cultural remains have been earthed from several Late Paleolithic sites in China in association with traditional core-flake and pebble tools, which has added more fuel to discussions of the nature of modern human behavior and the complex relationships between behavioral modernity and cultural variability.

The Upper Cave at the Zhoukoudian site-complex in North China is a good example of the rich relationships between archaeological discoveries and the emergence of behavioral modernity in that area. Polished bone tools, engravings on antler, personal ornaments and the use of ocher were found in the cave in association with early modern human skulls and simple core-flake tools. Bone tools include delicate polished bone eyed needles, attesting to the sophistication of bone tool manufacture there. Personal ornaments include perforated pebbles, mammal teeth,

tubular bones and perforated shells[61]. The cultural horizons at the site have been recently reliably dated to at least 35.1-33.5 kaBP, which is associated with the earliest known polished bone tool and ornaments in China[46]. The association of archaic and simple lithic artifacts with early modern human fossils, bone tools, antler engravings, personal ornaments and the use of ocher in one cultural horizon clearly indicates that lithic industries alone may not be sufficient to ascertain the identity of particular human groups, including archaic versus modern humans. Once again, we are reminded that the uniquely human co-evolutionary pathways of biology and culture tell separate stories that require integration and reconciliation in order to fully comprehend the nature of human origins and development.

Items of personal adornment have also been collected from the Shuidonggou site complex. The earliest ornament unearthed from the site is a perforated freshwater shell bead from Cultural Layer 3 at SDG 2, dated to 34-33 kaBP[37]. A total of 93 ostrich eggshell(OES) beads was found in slightly younger cultural horizons at SDG 2, 7 and 8[38,62]. Most of

Fig.3 Bone tools from the Ma'anshan site[63]

Bone artifacts recovered at Ma'anshan from Stratum 3(n.1-7), Stratum 5(n.8-13), Stratum 6(n.14-16), and out of context(n.17)

them derived from Cultural Layer 2 at SDG 2, which is dated to 33-31 kaBP. Both well-made and poorly crafted OES beads were produced at SDG 2. Detailed morphological and technological analyses made it clear that these OES beads derive from the extinct ostrich, *Struthio anderssoni*. Based on microscopic examination, morphometric analysis, and experimental replication, clear differences in morphology, size, technology, and style are identified. Research results indicate that the technology of bead making at SDG is similar to that used in most Middle and Later Stone Age sites in Africa and recorded ethnographically. Drilling experiments demonstrate that hafted stone points were probably used to make the perforations. A few beads show traces of deliberate polishing on their inner and outer surfaces. The morphology and technology of these OES beads suggest that distinct types of beads were made by different individual craftspeople, and that several human groups may have visited the SDG site and made and used such OES beads during the Late Paleolithic[62]. These people were certainly modern humans in every sense, yet they still made and used core-flake tools, obviously improved in comparison with earlier, simpler core-flake tools which dominated the technological repertoire in North China for a very long time.

An early occurrence of sophisticated polished bone tools has been discovered in Ma'anshan Cave site in Guizhou Province, South China, where at least 17 bone tools were unearthed from three cultural horizons. Three sharpened bone awls were collected from Stratum 6, dated to cal. 35 kaBP, and six probable spear points, awls and a cutting tool were discovered from Stratum 5, dated to cal. 34 kaBP. Stratum 3, dated to cal. 23-18 kaBP, yielded two types of barbed points. These bone tools were fabricated by a combination of scraping, grinding, and polishing. Ma'anshan has produced one of the oldest formal bone tool industries in China, including some of the oldest known indisputable evidence of the manufacture of barbed points outside of Africa[63].

Formal bone tools are nearly ubiquitous at Upper Paleolithic archaeological sites in Europe, and their production has long been regarded as an innovation introduced by anatomically modern humans from Africa colonizing this region ca. 40 kaBP[64]. Occurrences of polished bone tools in China dating to roughly 35 kaBP exhibit rates of cultural turnover comparable to those observed in the Upper Palaeolithic of Europe, indicating that the emergence of this key cultural innovation is better understood as a complex, discontinuous process that took place at different times in different regions, which needs to be documented on a regional scale, and which may be the outcome of both diffusion and independent invention[63]. The two cases of the early appearance of polished bone tools in the Upper Cave at Zhoukoudian in North China and the Ma'anshan site in South China reflect a similar cultural pattern, that is, sophisticated bone tools found in association with lithic technology that had remained relatively unchanged through a long period of time which, once again, testifies to the complexity of Late Paleolithic cultures in China and the ambiguity of the material expression of human behavioral modernity.

5. Evidence of the unprecedented capacity for adaptation of early modern humans

Modern humans developed rapidly during the Late Pleistocene. Along with improvements in their physical capabilities, cognition, technology and social organization, humans engaged in successful biogeographic expansions, eventually spreading even to extreme high-altitude environments. Successful adaptions to high altitudes have always presented humans with severe biological challenges. The Tibetan Plateau is the highest and one of the most challenging environments inhabited by humans. The combination of high altitude, atmospheric hypoxia, cold year-round temperatures, and low rainfall creates an extremely challenging environment for human habitation. Archaeological evidence indicates that it is one of the last terrestrial habitats colonized by *Homo sapiens* and today the Tibetan Plateau is the third least-populous spot on the planet(after Antarctica and Greenland). The peopling of Tibetan Plateau provides compelling

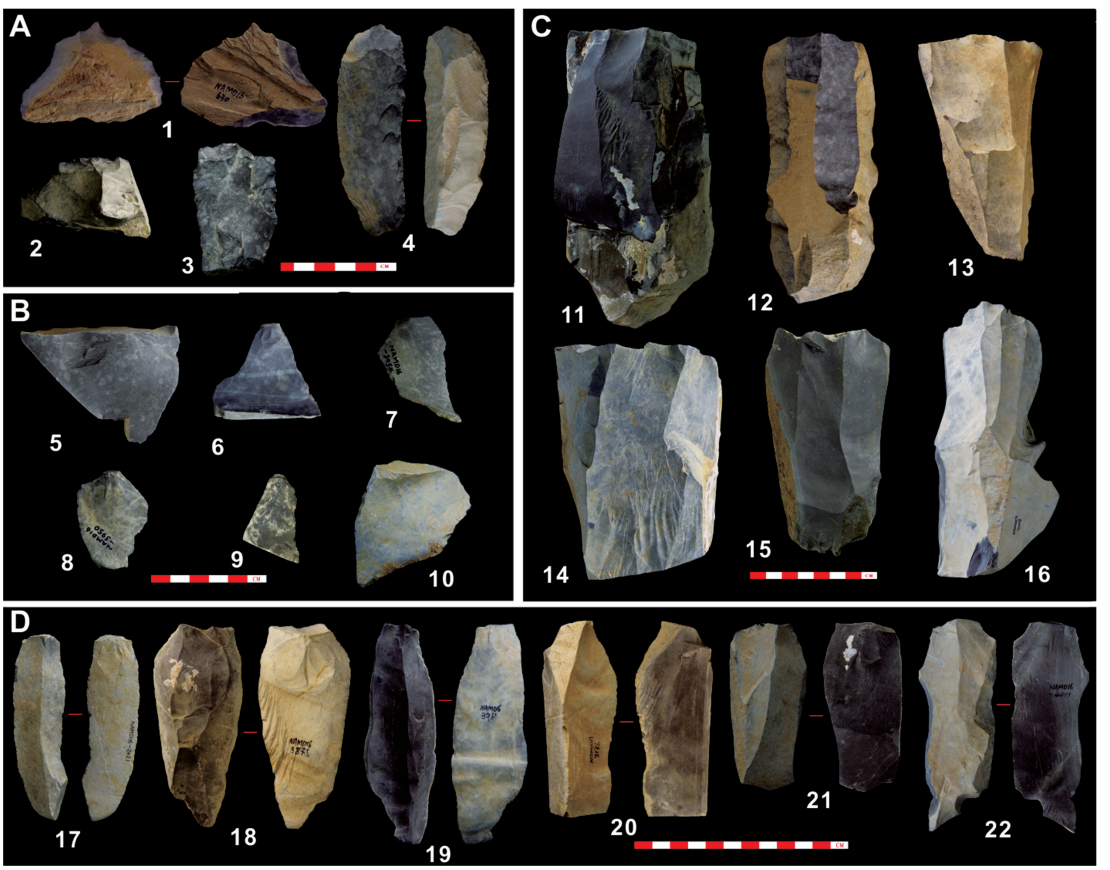

Fig.4 Lithic artifacts unearthed at Nwya Devu[52]

A)Tools//1, 2. Awl and side scraper, from Layer 1; 3, 4. side scrapers, Layer 3; B) Flakes//5, 6. Layer 1; 7, 8. Layer 2; 9, 10. Layer 3; C) Blade cores//11, l2. Layer 1; 13. Layer 2; 14-16. Layer 3; D) Blades//17. Layer 1; 18,19. Layer 2; 20-22. Layer 3

evidence for the unprecedented capacity for adaptation of early modern humans.

Until recently, there has been no concrete evidence of people inhabiting the interior of the Tibetan Plateau before the Holocene epoch and only a few reliably dated Pleistocene archaeological sites have been discovered around the Plateau's margins[65]. In 2013, the Nwya Devu open-air site, located on an ancient lacustrine terrace of Co Ngoin in the Nagqu district of interior Tibet, was discovered and subsequent formal excavations were carried out in 2016-2018. Fieldwork and laboratory analyses yielded multiple reliable dates in direct association with buried artifacts, extending back the history of human occupation of the region to 40-30 kaBP. The site, situated nearly 4600 masl, is the highest Paleolithic archaeological site yet identified, globally. A total of 3683 stone artifacts was recovered from an excavated area of 20 m^2. The lithic assemblage comprised 91 blade cores, 57 flake cores, 499 blades, 1,814 flakes, 195 tools and 1,027 chunks. The slate raw material was sourced nearby on Nwya Devu Hill where an outcrop is exposed on the surface. Based on the analysis and comparison of thin sections of unearthed artifacts and rocks collected at nearby outcrops, researchers concluded that the ancient inhabitants of Nwya Devu exploited the fine-grained slate exposed on the west slope of Nwya Devu Hill and knapped it exclusively[52].

The Nwya Devu lithic complex is distinguished by the production of blades from prismatic rather than Levallois cores. Comparing the length×width of the flaking face with the length by width and length by thickness of blade cores, indicates that people intended to detach blades from the long narrow face of nuclei. Unidirectional flaking dominates the Nwya Devu assemblage while blade size varies considerably. The Nwya Devu assemblage is principally comprised of flakes, blades, cores and chunks; formal tools are comparatively rare(only 5.3% of the collection). Finely retouched formal tools are scarce, and most retouch is expedient. The abundance of prismatic blade cores at Nwya Devu is therefore nearly unique in China. Technologically, the Nwya Devu lithic assemblage most closely resembles those classified as Early Upper Paleolithic(EUP) in southern Siberia and northern Mongolia and is differentiated from core-flake assemblages common in northern China. The blade cores, blades and tools from Nwya Devu, which include unidirectional as well as bidirectional nuclei for the production of medium-large size blades, share similarities with artifacts from early Upper Paleolithic sites in the Siberian Altai region, such as Kara Bom(Variant 1), and Tolbor-21(Layer 3a) in Mongolia[66-69].

Research on the Nwya Devu site deepens considerably the history of the peopling of the "Roof of the World" and the antiquity of human high-altitude occupations more generally. It demonstrates that despite cold temperatures and low-oxygen conditions at least 40-30 kaBP, hunter-gatherers colonized extreme high-altitude Tibetan Plateau environments in the Late Pleistocene. Thus, the Nwya Devu site establishes a new record for the prehistoric conquest of one of the most challenging environments in the history of modern human evolution; much earlier than current evidence from the Andes for high altitude colonization there[70].

6. Discussion and conclusions

In the past 30 years, hypotheses concerning the origins of modern humans have been intensively debated, and two competing models, the “Recent Out-of-Africa” and “Multiregional Evolution” paradigms, have dominated research and discussions for decades. Evidence from China has played a fundamental role in this debate: regional continuity and replacement by populations in-migrated from Africa have both been suggested and supported mainly by paleoanthropologists and geneticists, respectively. Recent discoveries of new human fossils, Paleolithic archaeological materials, and ancient DNA evidence in China have yielded a large body of information regarding the origins and evolution of modern humans in this region and concrete progress has been made in this broad and rich field.

New paleoanthropological and Paleolithic archaeological discoveries have drastically changed theoretical perspectives on modern human origins, evolution and adaptations. From an anatomical point of view, some archaic *Homo sapiens* groups found in China, such as those represented by fossils from the Hualongdong, Dali, Jinniushan, Dadong, Xujiayao and Xuchang sites[17, 20, 71-74], exhibit mosaic or transitional features while some(i.e., Xujiayao and Xuchang) indicate possible admixture with Neanderthals and Denisovans. Together with the continuous development of traditional core-flake technologies in North China and the pebble tool techno-complex in South China, such evidence lends credence to a “Continuity with Hybridization” model of modern human evolution in China. However, the morphological and genetic evidence of early modern humans from the Zhoukoudian Upper Cave and Tianyuan Cave reveals a very complicated history of genetic inheritance and hybridization with other hominin groups in western Eurasia, including both modern and archaic groups.

A blade-based techno-complex appeared at some sites in northern China by ca. 40 kaBP, indicating possible technological ties with lithic industries in southern Siberia and Central Asia as well as possible human in migration and interbreeding. When we aggregate available archaeological discoveries, including the association of refined traditional core-flake tools with bone tools and ornaments in North China and the persistence of a pebble-based industry in combination with the development of bone tools in South China, a very complex picture of modern human origins and evolution emerges.

Nevertheless, many problems could impinge on the validity of this model, including inadequate data relating to research on modern human origins and dispersals in northern China, the virtual hiatus in China’s human fossil record between roughly 100-50 kaBP, and the uncertain relationship between archaeological assemblages and specific fossil human groups. It is clear

that one of the major tasks that must be undertaken in northern China is the search for more archaeological sites and human fossils dating to 100-30 kaBP.

The study of modern human origins and evolution is a joint venture including many research fields. Every discipline engaged in this study is characterized by its own inherent strengths and weaknesses[75]. Archaeological material is abundant and much richer than is the human fossil record, but only the latter can provide morphological and genetic information, while material cultural remains can provide a large body of information which can help answer questions such as when hominins first appeared in a certain region, where they dispersed to, whether human evolution in a certain region was continuous or not, what ecosystems and adaptation strategies were exploited, and whether or not interaction among ancient human groups occurred. However, this data-set's weakness is its lack of unequivocal association with particular human ancestral groups or hominin evolutionary stage. Moreover, cultural behavior can be shaped by the environment and availability of raw materials, indicating great variability in the mechanisms of change, and are only very weakly correlated with anatomical and genetic evolution. Consequently, strengthening communication and interaction among traditional paleoanthropological and archaeological realms of inquiry and the burgeoning molecular biological fields, understanding each discipline's specialties and limitations, and carrying out inter-disciplinary and integrative research, is the right direction to follow in pursuing research on human origins and evolution in the future.

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References

[1] Cann RL, Stoneking M, Wilson AC. Mitochondrial DNA and human evolution[J]. Nature, 1987, 325: 31-36

[2] Stringer C. Modern human origins: Progress and prospects[J]. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences, 2002, 357: 563–579

[3] Wolpoff MH, Wu XZ, Thorne AG. Modern *Homo sapiens* origins: A general theory of hominid evolution involving the fossil evidence from East Asia[A]. In: Smith F H, Spencer F, eds. The Origins of Modern Humans: A World Survey of the Fossil Evidence[C]. New York: Alan R Liss Inc. 1984, 411-483

[4] Wolpoff MH, Hawks J, Caspari R. Multiregional, not multiple origins[J]. American Journal of Physical Anthropology, 2000, 112: 129-136

[5] Wu XZ. Origin of modern humans of China viewed from cranio-dental characteristics of Late *Homo sapiens* in China[J]. Acta Anthropologica Sinica, 1998, 17: 276-282(in Chinese)

[6] Wu XZ. Evidence of multiregional human evolution hypothesis from China[J]. Quaternary Sciences, 2006, 26: 702-709(in Chinese)

[7] Gao X, Zhang XL, Yang DY, et al. Revisiting the origin of modern humans in China and its implications for global human evolution[J]. Science China: Earth Sciences, 2010, 53: 1927-1940

[8] Green RE, Krause J, Briggs AW, et al. A draft sequence of the Neandertal genome[J]. Science, 2010, 328: 710-722

[9] Fu Q, Li H, Moorjani P, et al. Genome sequence of a 45000-year-old modern human from Western Siberia[J]. Nature, 2014, 514: 445-449

[10] Fu Q, Hajdinjak M, Moldovan OT, et al. An early modern human from Romania with a recent Neanderthal ancestor[J]. Nature, 2015, 524: 216-219

[11] Vernot B, Akey JM. Resurrecting surviving Neandertal lineages from modern human genomes[J]. Science, 2014, 343: 1017-1021

[12] Smith FH, Falsetti AB, Donnelly SM. Modern human origins[J]. American Journal of Physical Anthropology, 1989, 32: 35-68

[13] Smith FH, Janković I, Karavanić I. The assimilation model, modern human origins in Europe, and the extinction of Neandertals[J]. Quaternary International, 2005, 137: 7-19

[14] Gao X, Peng F, Fu QM, et al. New progress in understanding the origins of modern humans in China[J]. Science China: Earth Sciences, 2017, 60(12): 2160-2170

[15] Shea JJ. *Homo sapiens* is as *Homo sapiens* Was[J]. Current Anthropology, 2011, 52: 1-35

[16] Liu W, Jin CZ, Zhang YQ, et al. Human remains from Zhirendong, South China, and modern human emergence in East Asia[J]. Proceedings of National Academy of Science USA, 2010, 107: 19201-19206

[17] Li ZY, Wu XJ, Zhou LP, et al. Late Pleistocene archaic human crania from Xuchang, China[J]. Science, 2017, 355: 969-972

[18] Liu W, Wu XZ, Li YY, et al. Evidence of fire use of late Pleistocene humans from the Huanglong Cave, Hubei Province, China[J]. Chinese Science Bulletin, 2009, 54: 256-264

[19] Liu W, Martinón-Torres M, Cai YJ, et al. The earliest unequivocally modern humans in southern China[J]. Nature, 2015, 526: 696-699

[20] Liu W, Schepartz LA, Xing S, et al. Late Middle Pleistocene hominin teeth from Panxian Dadong, South China[J]. Journal of Human Evolution, 2013, 64: 337-355

[21] Fu Q, Meyer M, Gao X, et al. DNA analysis of an early modern human from Tianyuan Cave, China[J]. Proceedings of National Academy of Science USA, 2013, 110: 2223-2227

[22] Ke Y, Su B, Song X, et al. African origin of modern humans in East Asia: A tale of 12,000 Y chromosomes[J]. Science, 2001, 292: 1151-1153

[23] Ke YH, Su B, Li HY, et al. Y-chromosome evidence for no independent origin of modern human in China[J]. Chinese Science Bulletin, 2001, 46: 935-937

[24] Gao X. Archaeological evidence for evolutionary continuity of Pleistocene humans in China and East Asia and related discussions[J]. Acta Anthropologica Sinica, 2014, 33: 237-253(in Chinese)

[25] Wu XZ, Xu X. The origin of modern humans in China viewed from the Paleolithic data and Daoxian human fossils[J]. Acta Anthropologica Sinica, 2016, 35: 1-13(in Chinese)

[26] Wu X. Discussion on the results of some molecular studies concerning the origin of modern Chinese[J]. Acta Anthropologica Sinica, 2005, 24(4): 259-269(in Chinese)

[27] Gao X, Wang HM, Pei SW, et al. Shuidonggou: Archaeological Excavations and Research Reports for 2003-2007[M]. Beijing: Science Press, 2013(in Chinese)

[28] Peng F, Guo J, Lin S, et al. The onset of Late Paleolithic in North China: An integrative review of the Shuidonggou site complex, China[J]. L'Anthropologie, 2018, 122(1): 74-86

[29] Li F, Kuhn SL, Bar-Yosef O, et al. History, chronology and techno-typology of the Upper Paleolithic sequence in the Shuidonggou area, northern China[J]. Journal of World Prehistory, 2019, 32(2): 111-141

[30] Li F, Kuhn SL, Gao X, et al. Re-examination of the dates of large blade technology in China: A comparison of Shuidonggou Locality 1 and Locality 2[J]. Journal of Human Evolution, 2013, 64: 161-168

[31] Li F, Kuhn SL, Olsen JW, et al. Disparate stone age technological evolution in North China: Lithic technological variability and relations between population during MIS 3[J]. Journal of Anthropological Research, 2014, 70: 35-67

[32] Peng F, Wang HM, Gao X. Blade production of Shuidonggou Locality1(Northwest China): A technological perspective[J]. Quaternary International, 2014, 347: 12-20

[33] Guan Y, Gao X, Wang HM, et al. Spatial analysis of intra-site use at a Late Paleolithic site at Shuidonggou, Northwest China[J]. Chinese Science Bulletin, 2011, 56: 3457-3463

[34] Guan Y, Gao X, Li F, et al. Modern human behaviors during the late stage of the MIS3 and the broad spectrum revolution: Evidence from a Shuidonggou Late Paleolithic site[J]. Chinese Science Bulletin, 2012, 57: 379-386

[35] Peng F, Gao X, Wang HM, et al. An engraved artifact from Shuidonggou, an Early Late Paleolithic Site in Northwest China[J]. Chinese Science Bulletin, 2012, 57: 4594-4599

[36] Zhou ZY, Guan Y, Gao X, et al. Heat treatment and associated early modern human behaviors in the Late Paleolithic at the Shuidonggou site[J]. Chinese Science Bulletin, 2013, 58: 1801-1810

[37] Wei Y, d'Errico F, Vanhaeren M, et al. An Early Instance of Upper Palaeolithic Personal Ornamentation from China: The Freshwater Shell Bead from Shuidonggou 2[J]. PLoS ONE, 2016, 11(5): e0155847

[38] Martía AP, Wei Y, Gao X, et al. The earliest evidence of coloured ornaments in China: the ochred ostrich eggshell beads from Shuidonggou Locality 2[J]. Journal of Anthropological Archaeology, 2017, 48: 102-113

[39] Wang YP, Qu TL. New evidence and perspectives on the Upper Paleolithic of the Central Plain in China[J]. Quaternary International, 2014, 347: 176-182

[40] Wang Y. Late Pleistocene Human Migrations in China[J]. Current Anthropology, 58(Supplement 17): s504-s513

[41] Gao X, Pei SW. An archaeological interpretation of ancient human lithic technology and adaptive strategies in China[J]. Quaternary Sciences, 2006, 26: 504-513(in Chinese)

[42] Chu J, Huang W, Kuang S, et al. Genetic relationship of populations in China[J]. Proceedings of the National Academy of Sciences USA, 1998, 95: 11763-11768

[43] Martinón-Torres M, Wu X, Castro JMBD, et al. *Homo sapiens* in the eastern Asian Late Pleistocene[J]. Current Anthropology, 2017, 58: S434-S448

[44] Bae CJ, Wang W, Zhao J, et al. Modern human teeth from Late Pleistocene Luna Cave(Guangxi, China)[J]. Quaternary International, 2014, 354, 169-183

[45] Shang H, Tong HW, Zhang SQ, et al. An early modern human from Tianyuan Cave, Zhoukoudian, China[J]. Proceeding of National Academy of Sciences USA, 2007, 104: 6573-6578

[46] Li F, Bae CJ, Ramsey CB, et al. Re-dating Zhoukoudian Upper Cave, northern China and its regional significance[J]. Journal of Human Evolution, 2018, 121: 170-177

[47] Harvati K. Into Eurasia: A geometric morphometric reassessment of the Upper Cave(Zhoukoudian) specimens[J]. Journal of Human Evolution, 2009, 57: 751-762

[48] Yang MA, Gao X, Theunert C, et al. 40,000-year-old individual from Asia provides insight into early population structure in Eurasia[J]. Current Biology, 2017, 27: 3202-3208

[49] Bae CJ, Petraglia MD, Douka K. On the origin of modern humans: Asian perspectives[J]. Science, 2017, 358(6368): eaai9067

[50] Li F, Vanwezer N, Boivin N, et al. Heading north: Late Pleistocene environments and human dispersals in central and eastern Asia[J]. PLoS ONE, 2019, 14(5): e0216433

[51] Li F, Chen FY, Wang YH, et al. Technology diffusion and population migration reflected in blade technologies in northern China in the Late Pleistocene[J]. Science China: Earth Sciences, 2016, 59: 1540-1553

[52] Zhang XL, Ha B, Wang SJ, et al. The earliest human occupation of the high-altitude Tibetan Plateau 40-30 thousand years ago[J]. Science, 2018, 362(6418): 1049-1051

[53] Li F, Kuhn SL, Chen FY, et al. The easternmost Middle Paleolithic(Mousterian) from Jinsitai Cave, North China[J]. Journal of Human Evolution, 2018, 114: 76-84

[54] Institute of Archaeology and Cultural Relics of Xinjiang, School of Archaeology and Museology of Peking University. Tongtiandong site in Jimunai, Xinjiang[J], Archaeology(Kaogu), 2018,(7): 723-734(in Chinese)

[55] Hublin JJ. What can Neanderthals tell us about Modern Origins[A]? In: Mellars P, Boyle K, Bar-Yosef O, Stringer C eds. Rethinking the Human Revolution: New Behavioural and Biological Perspectives on the Origin and Dispersal of Modern Humans[C]. McDonald Institute for Archaeological Research, Cambridge, 2007: 235-248

[56] Krause J, Fu Q, Good JM, et al. The complete mitochondrial DNA genome of an unknown hominin from southern Siberia[J]. Nature, 2010, 464: 894-897

[57] Reich D, Patterson N, Kircher M, et al. Denisova admixture and the first modern human dispersals into Southeast Asia and Oceania[J]. The American Journal of Human Genetics, 2011, 89: 516-528

[58] Prüfer K, Racimo F, Patterson N, et al. The complete genome sequence of a Neanderthal from the Altai Mountains[J]. Nature, 2014, 505: 43-49

[59] Slon V, Hopfe C, Weiß CL, et al. Neandertal and Denisovan DNA from Pleistocene sediments[J]. Science, 2017, 356: 605-608

[60] Slon V, Mafessoni F, Vernot B, et al. The genome of the offspring of a Neanderthal mother and a Denisovan father[J]. Nature, 2018, 561: 113-116

[61] Pei WC. On the Upper Cave industry[J]. Palaeontologica Sinica, 1939, 9: 1-59

[62] Wei Y, d'Errico F, Vanhaeren M, et al. A technological and morphological study of Late Paleolithic ostrich eggshell beads from Shuidonggou, North China[J]. Journal of Archaeological Science, 2017, 85: 83-104

[63] Zhang SQ, d'Errico F, Backwell LR, et al. Ma'anshan Cave and the origin of bone tool technology in China[J]. Journal of Archaeological Science, 2016, 65: 57-69

[64] Klein RG. The Human Career: Human Biological and Cultural Origins(third edition)[M]. Chicago: University of Chicago Press, 2009

[65] Brantingham J, Ma HZ, Olsen J, et al. Speculation on the timing and nature of Late Pleistocene hunter-gatherer colonization of the Tibetan Plateau[J]. Chinese Science Bulletin, 2003, 48(14): 1510-1516

[66] Derevianko AP, Petrin V, Rybin E. The Kara-Bom site and the characteristics of the Middle-Upper Paleolithic transition in the Altai[J]. Archaeology, Ethnology and Anthropology of Eurasia, 2000,(2): 33-52

[67] Derevianko AP, The Upper Paleolithic in Africa and Eurasia and the origin of anatomically modern humans[M]. Institute of Archaeology and Ethnography SB RAS Press, Novosibirsk, 2011

[68] Rybin E, Zwyns N, Gunchinsuren B, et al. Issledovanija mnogoslojnoj paleoliticheskoj stojanki Tolbor-21(severnaja mongolija)(Investigation of the multilayered Paleolithic site, Tolbor 21)[A]. In: Derevianko A, Molodin V eds. Problems of Archaeology, Ethnography and Anthropology in Siberia and Neighboring Territories 21[C]. Institute of Archaeology and Ethnography SB RAS Press, Novosibirsk, 2015:152-156

[69] Khatsenovich A, Rybin E, Gunchinsuren B, et al. New evidence for Paleolithic human behavior in Mongolia: the Kharganyn Gol 5 site[J]. Quaternary International, 2017, 442: 78-94

[70] Rademaker K, Hodgins G, Moore K, et al. Paleoindian settlement of the high-altitude Peruvian Andes[J]. Science, 2014, 346(6208): 466-469

[71] Wu XJ, Pei SW, Cai YJ, et al. Archaic human remains from Hualongdong, China, and Middle Pleistocene human continuity and variation[J]. Proceeding of National Academy of Sciences USA, 2019, 116(20): 9820-9824

[72] Athreya S, Wu X. A multivariate assessment of the Dali hominin cranium from China: morphological affinities and implications for Pleistocene evolution in East Asia[J]. American Journal of Physical Anthropology, 2017, 164: 679-701

[73] Wu XJ, Crevecoeur I, Liu W, et al. Temporal labyrinths of eastern Eurasian Pleistocene humans[J]. Proceedings of the National Academy of Sciences USA, 2014, 111(29): 10509-10513

[74] Chen TM, Quan Y, En W. Antiquity of *Homo sapiens* in China[J]. Nature, 1994, 368: 55-56

[75] Gao X. Collaboration and integration among paleoanthropology, archaeology and genetics[J]. Acta Anthropologica Sinica, 2017, 36(1): 131-140(in Chinese)

中国现代人起源与演化的考古学思考

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摘要：越来越多古人类学和旧石器时代考古学的发现与研究成果极大地改变了我们对现代人类起源、演化和适应理论问题的看法。中国作为东亚一个幅员辽阔的地理区域，已经成为这项研究的热点地带。来自该地区新的人类化石和石器组合对基于非洲和欧亚大陆西部记录构建的“现代人出自非洲说”（Recent Out-of-Africa）提出了挑战。新的古人类学研究结果表明，早期现代人出现于约 100 kaBP 的中国南方，可能（至少部分）是由那里的土著居民演化而来。一些古老型智人表现出了与早期古人类镶嵌或过渡性的体质特征，并可能与尼安德特人和丹尼索瓦人杂交混合。同时一些遗址出土的打制石器表现出了早期现代人类技术和行为的复杂性。中国北方的小石片石器主工业和南方的砾石石器主工业贯穿于整个更新世，然而从约 40 kaBP 开始，石叶技术开始出现在中国北部，紧随其后的是这些地区骨制工具和个人装饰品的出现，这表明，更新世晚期西伯利亚和中亚地区与我国北部可能存在着紧密的文化关系，东北亚地区可能存在着由西北向东南的迁移路线。人类化石和考古学证据表明，中国现代人类起源和适应的过程与机制可能与欧亚大陆西部有所不同。本文对有关中国现代人类起源与演化的考古学研究所取得的新发现和进展进行了总体回顾，从考古学角度阐述了对相关重要学术问题的看法，并为未来的研究提出了方向性建议。

关键词：中国；现代人起源与演化；行为现代化与复杂化；连续进化附带杂交