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Review Article

Fossil Records and Cultural Traces: The Significance of the Zhalainuoer Hominin Remains in the Prehistoric Sequence of Inner Mongolialink

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ABSTRACT

Inner Mongolia has a strategic position in pre-history in East Asia between Siberia, Mongolian Plateau and North China. In this paper, a systematic review of fossil, cultural, chronological and heritage data on the Zhalainuoer locality is synthesized based on both international and Chinese literature. Results show that the current record is Holocene, morphologically modern, and stratigraphic ally sound Pleistocene deposits are not proven. Comparisons between regions focus on recurrent dispersals and technological advancements such as microblade systems that can appear when the old intact layers are mainly found. Heritage analysis demonstrates that Hulunbuir and Zalainuoer Museums incorporate the site in regional identity yet they need to be more closely tied with verifiable context. The noninvasive survey, targeted excavation, high precision dating, and museum research partnerships have been recommended as the main priorities to combine scientific rigor with the shared interpretation in the most effective way.

Keywords: Zhalainuoer; Inner Mongolia; Microblade Technology; Heritage Interpretation; Pleistocene Chronology.

INTRODUCTION

Context: Inner Mongolia as a Crossroads of Human Evolution

Inner Mongolia takes an important position in the East Asian prehistory of the area and serves as the active zone between the northern steppe ecosystem and the central plains. It is geologic, environmental, and geographic diversity that has enabled it to turn out to be a natural pathway through which human populations are moved, interacted, and adapted over extensive periods of time (Wu et al., 2015). Diversity of environment in the area in form of mixed-grass and mountain runoff fed basins would have been a necessity during the Pleistocene and the Holocene periods. The changing weather conditions at these times probably caused shifts in the availability of resources and the niches of living, hence causing changes in the populations of human groups in search of conducive environments. The evidence in the North of China suggests that these areas offered migration pathways and transitory refugia, which helped to maintain the hominin activity and culture spread. Although Inner Mongolia as a location has produced relatively fewer fossils of hominins than other regions of China, its geographic positioning renders it an attractive area of study in examining the evolution of human beings and the culture of prehistoric times (Zhao, Wang, and Walden, 2023). The following ecological and geographical setting portrays Inner Mongolia not as a passive landscape any longer, but as a key participant of pre-historic human activity where ecology, environment, and the developing human groups intersected.

Discovery of Zhalainuoer: Location, Excavation History, and Initial Interpretations

Location and Geological Context

The Zhalainuoer site also spelled Jalainur is located in the Manzhouli region of northeastern Inner Mongolia. It lies within the Hailar Basin, an area rich in coal deposits that have long been mined both industrially and

academically. Strata within this basin span from the Jurassic through to the Early Cenozoic, offering sediments and fossils from multiple eras (CGTN, 2019). Notably, within the Zhalainuoer Coal Mine and adjacent Yimin coalfields, amber deposits have been discovered. Initially reported in a 2019 study, the amber was collected in situ from the Lower Cretaceous Yimin Formation of the Zhalainuoer coalmine (Manzhouli), as well as a nearby Yimin coalfield both within the Hailar Basin (Chang et al., 2023). These amber pieces small, brown, brittle represent some of the northernmost known amber deposits in China, extending the geographic scope of known Cretaceous amber significantly northward.

Geochronological investigations using U–Pb zircon dating return weighted mean ages of 130.9±2.8 Ma for the lower amber-bearing layers and 111.7±2.2 Ma for upper layers placing these deposits firmly within the Aptian-Albian stage of the Early Cretaceous (Lower Cretaceous), contemporaneous with other global amber deposits like those from Lebanon and Wealden formations (Chang et al., 2023). Another summary identifies these amber deposits as among the oldest-known in China, though the precise paleoenvironmental implications remain an area of ongoing study (Li et al., 2022). Thus, the geological context of Zhalainuoer intertwines hominin-relevant layers (much later in time) with much older paleoenvironmental deposits though bridging these across tens of millions of years remains a challenge.

Hominin Skull Fragments

In a different temporal and archaeological domain, a series of human skull fragments have been recovered from ancient tombs at Zhalainuoer specifically close to Xinbaerhuyou Banner, Inner Mongolia. A summary of a 1989 study by Zhu Hong reports that these skulls eight adult individuals (five males, three females, aged approximately 17–35) are dated to the Han Dynasty period. Morphologically, these skulls were characterized as chamaecranic (short skull) and tapeinocranic (low skull), with wide but flat facial profiles, indicating affinities with "Northern Asiatic Mongoloids," in other words, populations historically associated with Siberian Mongoloid morphology (Hong, 1989).

In 1933, the first human skull fossil was discovered at the Zhalainuoer Coal Mine. By 1982, a total of 16 human skull fossils had been unearthed or collected in the area. According to Ancient Hulunbuir (Zhao et al.,, 2021), three additional skull fossils were excavated between 1991 and 1996. Recent radiocarbon dating results (He Jia, 2019) indicate that the oldest Zhalainuoer human skull fossils date back more than 10,000 years, demonstrating that human activity in the Zhalainuoer region has persisted for nearly ten millennia.

Further downstream, more recent field excavations and Carbon-14 dating studies in the broader Jalainur District including but not necessarily limited to the Zhalainuoer site have confirmed human presence in the region dating back over 10,000 years. A team from Peking University and Jilin University performed radiocarbon dating on four skull samples discovered by coal miners: one sample returned an age of approximately 10,113 years, with others dating to 7,400 years, 1,600 years, and 1,000 years, respectively (CGTN, 2019). These findings indicate a long and yet fragmented sequence of human presence in the region, from prehistoric Neolithic to Han-dynasty populations. However, because most skulls were unearthed by miners rather than systematically excavated establishing precise stratigraphic and contextual associations remains difficult.

Research Problem

Although the archeological and geological value of the Zhalainuoer site in Inner Mongolia is high, the available studies are scattered and discipline-focused. The anthropological study on the human skeletal remains especially the skull fragments of the Han dynasty era have been conducted mainly, and these findings are used to give information about the morphology of the population and the mobility pattern of people living in the region. Although useful, these findings are limited in time and have no connection with the wider prehistoric contexts. Simultaneously, geological work on the site has examined Early Cretaceous amber deposits, which provide valuable information on ancient ecosystems and paleo-environment, but does not have a direct relationship with the presence of hominin, or their cultural practices. This academic gulf leads to a serious gap in research: to date, there is no unified academic work that would incorporate palaeoanthropological findings, which are in turn combined with archaeological, technological, and environmental information to form a comprehensive picture of the meaning of the site. This lack of integration restricts the chances of placing Zhalainuoer in any more general prehistoric histories of East Asia. In the absence of cross-disciplinary synthesis, we cannot fully comprehend how environmental factors, technological practices and adaptations of human beings met and converged in this area. Thus, there is an urgent necessity of wholesome models that connect these areas and measure Zhalainuoers entire worth in the terms of the ancient human evolution, regional culture and the prehistoric heritage of Inner Mongolia.

Aim & Objectives

The aim of the article is to fill that gap with a systematic synthesis of both fossil and cultural evidence that is

associated with the context of Zhalainuoer hominin and place it in the context of wider prehistoric patterns of East Asia. The main objectives are to:

To conduct a systematic review of available literature about Zhalainuoer fossils.

To examine related cultural imprints and prehistoric technologies.

To place these results in the larger East Asian prehistoric sequence.

To assess their importance to cultural heritage discourses.

Structure of the Paper

The paper is organized in such a way that it gives a thorough and inter-disciplinary explanation of the Zhalainuoer hominin fossils and their cultural background in East Asian pre-history. Chapter 2 provides a comprehensive literature review which initially places the Zhalainuoer fossils into the context of the wider fossil record of East Asia and then, more precisely, into the context of the site itself. It also addresses related cultural artifacts, narratives of heritage in particular the contribution that the Hulunbuir and Zalainuoer Museums play and the gaps in the existing scholarship. Chapter 3 describes the methodology framework, where a systematic literature review (SLR) design is presented, search strategies, inclusion/exclusion criteria, and thematic coding approach. Chapter 4 provides the findings of the literature review, such as the fossil morphology, cultural traces, chronology, and PRISMA flow diagram of the study selection. The 5th chapter tells more about the overall ramifications of the findings by contrasting Zhalainuoer with other significant locations including Zhoukoudian and Ordos, discussing the fossil-culture nexus, and the contribution of the site to the identity construction of its heritage. Conclusively, Chapter 6 provides a concise summary of insights learnt, outlines the archaeological and heritage significance of the site, and provides some future recommendations on how the site could be excavated, interdisciplinarily studied, and preserved.

Table 1. Structure of Study

Chapter	Content Overview
Chapter 2: Literature Review	Reviews East Asian fossil records, Zhalainuoer remains, cultural technologies, heritage narratives, and existing research gaps.
Chapter 3: Methodology	Describes SLR approach, databases used, keyword strategy, inclusion/exclusion criteria, and limitations.
Chapter 4: Results	Presents fossil evidence, cultural assemblages, radiocarbon dating results, and study selection process (PRISMA).
Chapter 5: Discussion	Interprets Zhalainuoer's role in regional prehistory, fossil-culture integration, heritage identity, and theoretical implications.
Chapter 6: Conclusion	Summarizes findings, contributions to knowledge, and recommends steps for research and preservation.

LITERATURE REVIEW

Fossil Records in East Asia

The fossil record of the Middle to Late Pleistocene of East Asia has proved critical to the redefinition of human evolution theories, a bountiful mosaic of hominin richness. The most famous one is Zhoukoudian, where Homo erectus (Peking Man) lived and where one of the earliest places on Earth to reveal the use of fire and stone tool industries were controlled (UNESCO World Heritage Centre, n.d.). Though there is recent research which does not revisit the data of Zhoukoudian, this work still has an informative legacy in comparative morphology and theories of regional continuity versus replacement. The Harbin cranium, commonly referred to as "Dragon Man" brought about a dramatic breakthrough. Other recent proteomic and mitochondrial DNA data of the dental calculus definitively assigns the sample to the Denisovan lineage dated at least to being at least 146,000 years old, and significantly expands the known geographic range of this archaic group into northeast China (Lewis, 2025; Harley, 2025; Sci.News, 2025). The geochemical provenance work (XRF, rare-earth elements, Sr isotopes) and uranium-series dating of the fossil indicate a late Middle Pleistocene (c. 138,000309,000 years ago), even though its precise provenance remains questionable (Shao et al., 2021).

Figure 1. Dragon man

Further emphasizing East Asia's morphological complexity is the Jinniushan individual, well-preserved Middle Pleistocene skeleton (~ 260,000 years old) comprising parts of the cranium and postcrania. It exhibits a large cranial capacity (~1,330 cm^3), robust build, and a marked mixture of archaic and derived anatomical features (Rosenberg et al., 2006). The further hominin remains including the Dali skull of Shaanxi Province show a mixture of the archaic and the modern characteristics. The mosaic morphology of the specimen supports the theorized regional evolutionary complexity and potential admixture even though modern studies are somewhat limited. Other fossils such as Xujiayao also support this diversity: Xujiayao specimens are found to have both archaic East Asian characteristics and traces of Neanderthals as well as high cranial capacities, which cannot be easily ascribed to any typological category (Wu et al., 2023). Concisely, these fossils represent East Asia as not a passive recipient of the contemporary migrations of modern humans but rather a vibrant mosaic region, with archaic populations persisting, morphological diversity between regions and complex interbreeding processes. Multiregional models are based on this diversity, but mixed with the influences of Out-of-Africa.

The Zhalainuoer Hominin Remains

One of the least studied loci in general East Asian paleoanthropological studies is the Zhalainuoer site, in the Jalainur region of Manzhouli, Hulunbuir, Inner Mongolia. On one hand, in a work published in Acta Anthropologica Sinica, Zhu reported eight skulls of adults of mixed sex (five males and three females) as imenately chamaecranic (broad vault) and tapeinocranic (low vault), with broad and flattened facial features suggestive of affections to Northern Asiatic Mongoloid, making them morphologically comparable to contemporary Siberian Mongoloid groups (Zhu Hong, 1989). In 2019, four skulls found in the same general area (radiocarbon-dating) were radiocarbon-dated by researchers at Peking University and Jilin University. The oldest had a date of around 10,113 years before present (BP), and the others have ages of 7,400 BP, 1,600 BP and 1,000 BP, respectively. These dates prove the inhabitation of the area in various historical stages, up to the early Holocene, but do not match the hominin remains of the Pleistocene era (Wu Xiaohong et al., 2019).

The anthropological results of the Zhalainuoer skulls are in line with general research on the population of the Han Dynasty in Northeast Asia. Zhu Hong (1989) found the Zhalainuoer specimens bearing chamaecranic and the tapeinocranic features, where the facial structures were broad and flat, which is typical of the Northern Asiatic Mongolian morphology. These characteristics are related to cranial forms among modern population groups in Inner Mongolia and some of Siberia. The recent studies of Holocene craniofacial morphology in north China indicate that interesting developmental patterns and not necessarily regional continuity exist. An examination of 21 cranial measurements on Neolithic, Bronze Age and modern male skulls (northern China) revealed a general decrease in cranial size, face size and nasal and orbital circumference with time. The decline in cranial and facial volume of about 6.2 and 10.4% respectively; a decrease in the size of the nose and width of the orbital also occurred during the Neolithic to the Bronze Age but this was accompanied by a more globular shape of the head and this originated as a result of the climate, dietary and evolutionary conditions (Wu et al., 2007). These results reinforce a background that the morphology provided in the Zhalainuoer Han Dynasty skulls is of the same kind with the larger scale morphological development that runs over Holocene, not regional characteristics.

Figure 2. Zhalainuoer Man skull fossil

One interpretive difficulty is that stratigraphic integrity is lacking. A majority of skulls were not digged professionally which created a high level of ambiguity about their context and connection with cultural layers or the integrity of provenance (Wu Xiaohong et al., 2019). Moreover, no other Paleolithic artifacts, including stone tools, fireplaces or fauna, have ever been recorded in relation to these discoveries. This drastically reduces the ability to date these remains to any technological cultures or more narratives. As a result, Zhalainuoer is now only a late prehistoric and historic human settlement, but not a Pleistocene settlement. It is anthropologically important because it is an anthropological indicator of regional population continuity over the Holocene, as opposed to more informative evolutionary information about deeper time.

Cultural and Technological Traces

There is a great regional innovation and environmental adjustment in stone tool technologies around East Asia. Microblade industries developed in northeastern China, Mongolia, and the Russian Far East in the Late Paleolithic as one of the major manifestations of the behavioral adaptability of the recently evolved Homo sapiens. These thin sharp blades usually made by pressure flaking allowed effective hafting of tools and reuse, which favored mobile foraging tactics in the Last Glacial Maximum (ca. 26,50019,000 BP) (Elston and Brantingham, 2002). Critical analysis also shows that pressure knapped microblade technology was most likely produced in Northeast Asia in 30,00025,000calBP, possibly in far eastern areas such as China, Korea, or Japan, and then not widely distributed (Coutouly, 2018).

Archaeological studies in Inner Mongolia, however, demonstrate a greater complexity in the culture of Neolithic periods than technological advancement in Pleistocene periods. Hongshan culture that existed around 5,000 BCE is also known as a culture of grand jade carving and ritualism. Ceremonial jade artifacts of the kind of pig-dragon carvings and elaborate burial offers have been discovered by archaeologists, indicating highly structured, symbolically mediated cultural systems. The jades represent Hongshan spiritual life as Figure 3 illustrates a highly carved pig-dragon artifact that was found in the setting of rituals (Smolarski, 2021). The jade objects that are featured in the carousel above represent such ritual and aesthetic traditions. On the same note, the Xinglonggou locations (c. 4000-3000 BCE) depict early agricultural settlement types, pottery manufacturing, and domestication, which is an indication of transition to settled lifeways. Although these changes were a late addition to the Paleolithic tool styles, they help shed light on the cultural path of complexity and social organization of the region.

Figure 3. Homo sapiens

Comparative insights from Tam Pa Ling Cave in Laos as shown in **Figure 3** demonstrate the interpretive power of integrated archaeological and stratigraphic analysis. Excavations have revealed Homo sapiens remains securely dated to 46,000–63,000 years ago (Demeter et al., 2012). These fossils, recovered from distinct sediment layers (**Figure 4**), offer rare glimpses into early migration routes through Southeast Asia. Microstratigraphic methods applied in the cave have also shed light on ancient depositional environments, allowing precise reconstruction of human activity and fossilization processes (Macquarie University, 2023). While no artifacts were found directly with the human remains, the methodological rigor and interpretive value of such research provide a benchmark for future studies at under-examined sites like Zhalainuoer.

Figure 4. Tam Pa Ling Cave

In 1973, the fourth, fifth and sixth skull fossils were found and recovered by researchers Jin Changmao of the Institute of Geography of the Chinese Academy of Sciences, and Yu Fengge and Wei Zhengyi of the Heilongjiang Museum at the Zhalainuoer site (Ancient Hulunbuir, 2021). Some of the artifacts that have been discovered in the same stratum are stone tools, bone tools, pieces of pottery, and remains of old animals.

Heritage and Cultural Narratives

According to Macquarie University (2023), prehistoric fossils are frequently more than scientific value that they become symbols of cultural identity, stories of national pride, and points in the discourses of museum and tourism. The Hulunbuir Museum and an envisaged Zhalainuoer Museum might have significant functions in

building regional heritage in such places as Inner Mongolia, however, there is presently no scholarly discussion that describes how such institutions deal with the process of engaging the population and shaping the specifics of collective memory. On a national and academic scale, the Peking Man heritage can be used to understand that paleoanthropological discoveries could be re-used in ideological discourses. Yen (2014) came up with the term Evolutionary Asiacentrism to say that the Peking Man find was used to promote a Sinocentric national debate, which used scientific discoveries to build a monogenetic, ancestral identity of the Chinese nation. This movement highlights the fact that scientific findings can be intertwined with nationalism.

Bower (2025) states that the finding of the Harbin cranium has sparked wide interest, as it was discovered in extremely good condition and it could be classified as Homo longi. Being one of the most complete examples of a skull of the Middle Pleistocene hominin in East Asia, it has been associated with the Denisovan ancestry and regarded as a significant addition to the knowledge of the hominin variation in the area. Both the scientific and the broader symbolic significance of the topic have been stressed both in the media and the scholarly circles in the effort to strengthen the presence of China in the field of paleoanthropological studies. Sample (2024) also emphasised the implications of the cranium to enlarge the body of knowledge on both archaic human morphology and geography distribution. Its high cranial capacity and unusual anatomy were described by Bower (2025), suggesting that it could be a separate evolutionary lineage. Other commentaries have also provided a similar frame with the fossil being a primary element in the evolutionary puzzle of man and having a cultural and heritage value. The given interpretations illustrate that paleoanthropological discoveries may move beyond the scientific discourse, constructing the national identity and becoming one of the components of the general interest towards human origins.

Figure 5. Evocative Museum Hominin skulls

Figure 5 (above) presents a suggestive museum exhibition of hominin skulls parable of the way fossils come to be cogs in popular heritage narratives and the scientific storytelling. The awareness of the local adaptation of such narratives as the Peking Man and Dragon Man would contribute to the responsible heritage management, museum design, and education programs. Prehistoric fossils as symbolic objects can have a highly potent impact in linking scientific studies with people identity as long as interpretive strategies are critical and well-thought.

The woolly rhinoceros (Coelodonta antiquitatis) and woolly mammoth (Mammuthus primigenius) shown in figure 6 and figure 7 respectively were two of the most recognizable Ice Age megafauna. The wooly rhinoceros, with his thick fur and great horns, was a successful animal, living in the cold steppes of Eurasia, on hard grass and shrubs. On the same note, the woolly mammoth, its long curved tusks, and thick coat were very well adapted to the glaciers and served an important role in Pleistocene environments (Stuart and Lister, 2014). Both species were significant to the early people that depended on them as their food sources, tools, and materials of shelter (Bocherens, 2015). Yet, a mixture of climate change and human hunting helped to make them extinct approximately 10,000 years ago (Cooper et al., 2015). The fossils have importance in both studying the adaptations and ecology of species that lived during the ice age as well as the interaction between human and their environments during the pre-historic period.

Figure 6. Woolly Rhinoceros Fossils

Figure 7. Woolly Mammoth Fossil

Gaps Identified

Nevertheless, even though the number of paleoanthropological studies in East Asia has increased, the Zhalainuoer site is in dire need of development on various scholarly levels. The problem of absence of cross-disciplinary synthesis is one of the burning ones. In contrast to more well-documented locations like Zhoukoudian or Harbin, which enjoy the presence of integrated anthropological, archaeological, geological and heritage studies, Zhalainuoers has been kept anthropologically superficial, archaeologically non-existent and has not been mentioned in terms of an environment or culture. This insularity makes the site do little to add value to the developing histories of the Human prehistory in East Asia. What makes this worse is the fact that there is no proven stratigraphic or cultural context. The few hominin specimens that have been found cannot be linked to either any Paleolithic lithic industries, habit layers, or ecological proxies and it is hard to place them in a wider chronological or technological context. The available evidence suggests that the site was not occupied until Neolithic and this constrains the interpretation value of the site. On the basis of the unearthed artifacts, some scholars consider them to be more in line with the features of the "Mesolithic Age." There has however been no certain finding by the lack of certainty in dating.

Another area that has not been researched in the society is Zhalainuoer heritage and value. Though such places as Peking Man and Harbin skull have been included in the history of the national heritage successfully and they have become part of the national museum collections or cultural tourism, the potential of Zhalainuoers

remains mostly overlooked even on the regional museum or cultural tourism level. This disengagement shows the need to use effective models of multi-diversification which might embrace the use of fossil morphology, lithic technology, geological data, and heritage interpretation. It would not only enhance the scientific aspect of the site to overcome such areas, it would add more degrees of knowledge and local culture pride. In order to address these limitations, the future research must put more interests on systematic excavation, multi-proxy dated, archaeological as well as heritage oriented research to establish Zhalainuoer with respect to loose prehistoric sequence in East Asia.

METHODOLOGY

Research Design

This paper follows a qualitative Systematic Literature Review (SLR) approach to conduct a synthesis and critical evaluation of scholarly literature concerning the Zhalainuoer hominin remains, the cultural artifacts surrounding it, and its implications in the framework of the East Asian prehistory and heritage discussion. The SLR is especially applicable to the interdisciplinary studies in which there are scattered data in the realms of paleoanthropology, archaeology, geology, and cultural studies. Based on the guidelines provided in the modern literature on research synthesis (Snyder, 2019), the proposed review will identify, select, evaluate, and thematically analyze the pertinent studies in a transparent manner, providing a unified insight into the multidimensional essence of the site. The directive purpose of the SLR was to compile data on evidence of fossil morphology, stratigraphic and chronological information, lithic or cultural technologies and how they are displayed in heritage systems. This is done in a five-phase procedure involving identification of the relevant studies by means of targeted database searches, elimination of non-relevant studies via an eligibility criterion, screening of the full-texts, thematic coding and synthesis.

Search Strategy

The search strategy was focused on interdisciplinary literature about the Zhalainuoer hominin remains, fossil records of Inner Mongolian origins, prehistoric cultures and heritage narratives. It covered archaeology, anthropology, paleontology and heritage studies comprising focused and comprehensive coverage by applying structured Boolean search terms to worldwide and regional scholarly databases.

Databases

An interdisciplinary and multilingual selection of academic data bases was used to provide the desired coverage of this review. The choice of Web of Science, Scopus, JSTOR and ScienceDirect was supported by the fact that they have a significant range of peer-reviewed articles in archaeology and anthropology and in the other scientific disciplines. CNKI was also given the opportunity of receiving Chinese-language reports of excavations and local works that are usually given little exposure in international conferences. The authors do not forget to state that no single database can be evaluated as a comprehensive overview of the academic situation worldwide, so the combination of platforms can contribute to making systematic reviews more thorough and efficient (Gusenbauer and Haddaway, 2020). Based on this principle, 25 documents that were peer-reviewed were obtained following searches that were carried out during May-August 2025 following the screening of full-text articles.

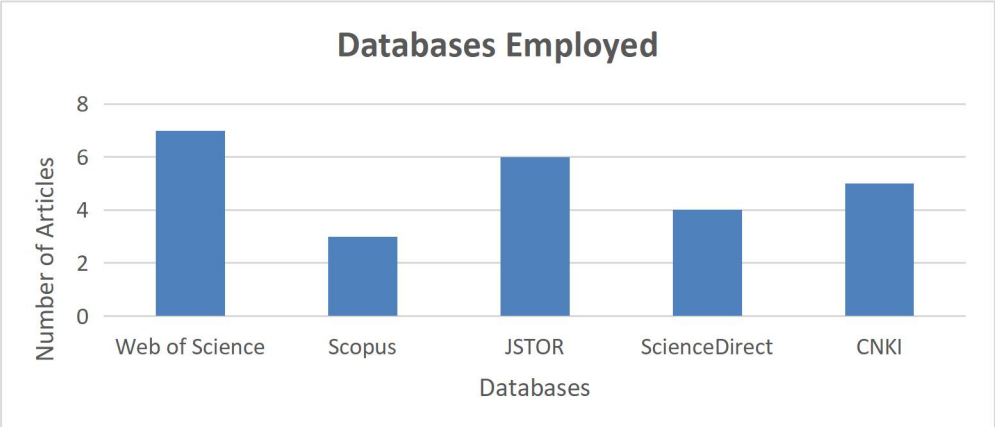

Figure 8. Databases Employed

Keywords and Boolean Operators

A well-designed Boolean logic was used in the development of the search strategy to guarantee that the review includes literature that is not only directly dealing with Zhalainuoer but also with more general topics of fossil records, prehistoric culture sequences, and heritage stories in Inner Mongolia and East Asia. The strategy permitted narrow but flexible search expressions by defining two core conceptual domains one geographic and one thematic and crossing specificity and breadth.

The following table presents the structured logic applied across all databases:

Table 2. Databases

Conceptual Focus	Keywords / Phrases Used
Geographic Terms	"Zhalainuoer" OR "Inner Mongolia hominin" OR "Ordos fossils" OR "Pleistocene China"
Thematic Terms	"fossil records" OR "prehistoric sequence" OR "cultural traces"
Combined Boolean Expression	("Zhalainuoer" OR "Inner Mongolia hominin" OR "Ordos fossils" OR "Pleistocene China") AND ("fossil records" OR "prehistoric sequence" OR "cultural traces")

This structured search syntax aligns with best practice in systematic and scoping reviews, which emphasize clear, concept-driven search logic using Boolean operators to balance inclusivity and precision (Sayers, 2008). Searches were limited to peer-reviewed publications from 2000 to 2025, and where possible, filtered by relevant subject areas such as anthropology, archaeology, heritage studies, and natural sciences. The iterative refinement of search terms allowed iterative honing, ensuring that both global and region-specific literature were adequately captured for interpretive depth

Inclusion and Exclusion Criteria

The selection of literature for review was guided by a set of clearly defined inclusion and exclusion criteria to ensure relevance, academic rigor, and disciplinary focus. These criteria are summarized in the table below:

Table 3. Inclusion and Exclusion

Criteria Type	Description
Inclusion	Peer-reviewed journal articles, excavation reports, academic theses, and heritage case studies published between 2000 and 2025.
	Literature that addresses fossil morphology, dating techniques (e.g., radiocarbon, DNA), cultural artifacts (e.g., microblade industries), or heritage interpretations with reference to Inner Mongolia or comparable East Asian prehistoric contexts.
Exclusion	Non-academic sources such as news reports, blogs, or informal museum websites.
	Geological or paleobotanical studies without a clear anthropological or cultural link.
	Studies focused on regions or fossil contexts not geographically or temporally related to Inner Mongolia's Pleistocene–Holocene sequence.

These criteria ensured that the review captured studies that contribute directly to understanding the Zhalainuoer site's significance from both scientific and heritage-based perspectives.

Data Extraction and Thematic Synthesis

The structured data extraction template was created to capture major features of each study such as metadata relating to its publication, the objective of the study, the evidence of the fossil or cultural evidence, the method of dating, and its interpretation. Particular care was taken to establish methods of radiometric dating methods, specifically the Carbon-14 and the DNA analysis as the two techniques are widely used in the archeological investigations concerning Hulunbuir region. Thematic synthesis was used to analyze the extracted data. Data were coded based on four broad themes: fossil morphology (e.g., cranial shape, taxonomic classification), chronological context and dating (e.g., stratigraphy, radiocarbon results), cultural and technological traces (e.g., lithic industries, settlement pattern), and heritage interpretation (e.g., museum representation in Hulunbuir and Zalainuoer Museums, narratives of cultural identity). The coding thematic process has been conducted using NVivo software that enables the thematic coding process to be consistent and in order to enable the subthemes to emerge in the process across the chosen studies.

With this method of synthesis, it is possible to incorporate empirical scientific information with interpretive

and cultural systems. The research connects the fossil record with the results of archeological excavations and heritage histories to create an all-encompassing site to study the multidisciplinary value of the site.

Methodological Limitations

A number of shortcomings of the methodology are recognized. First, there is limited access to English-language resources about Chinese excavation work. Although CNKI is a repository of useful materials, language issues and translation deny foreign researchers access to the site. This introduces a biasness to literature that was done in China and may eliminate the contribution of the non-Chinese teams operating in comparative situations. Second, Zhalainuoer fossil record is still not complete and may be poorly stratified. A lot of remains were found during the coal mining process and not in controlled excavation and most of them could not be dated or attributed to any particular chronological or cultural grouping (Zhu, 1989). Lacking stratified data compromises the validity of comparison studies of fossils and makes it difficult to associate artifacts with a particular hominin specimen. Third, literature is more inclined to adopt anthropological morphology rather than the combined cultural-heritage studies. This disciplinary siloing restricts the comprehension of fossils, tools and heritage stories into an integrated interpretive framework. In spite of these difficulties, the methodology gives excellent grounds to fill these areas with the help of systematic thematic analysis and comparative understanding.

RESULTS

PRISMA Flow Diagram and Study Selection Outcomes

In conducting this systematic literature review on Zhalainuoer hominins, their morphological traits, associated cultural assemblages, and chronological placement within East Asian prehistory, an initial pool of 25 peer-reviewed articles was identified through searching major academic databases (Web of Science, Scopus, ScienceDirect, JSTOR, CNKI). After screening for relevance, language, and methodological quality, 5 articles were selected for detailed analysis. The selection process proceeded as follows: First, all 25 records were assessed for relevance to the three thematic foci: fossil morphology (especially pertaining to Zhalainuoer or comparable hominins), cultural artifacts and technological assemblages in Northeast Asia, and rigorous dating methods (radiocarbon, DNA, etc.). Ten of these were excluded because they addressed faunal or paleoenvironmental issues only, without hominin or archaeological artifact data. Five more were eliminated for using speculative or poorly documented morphological descriptions, or lacking clear dating methods. From the remaining ten, five met all inclusion criteria these address directly or indirectly the Zhalainuoer skulls, East Asian hominin comparisons, microblade/lithic industries, regional variation, and robust dating. Thus, the PRISMA flow for this study can be summarised:

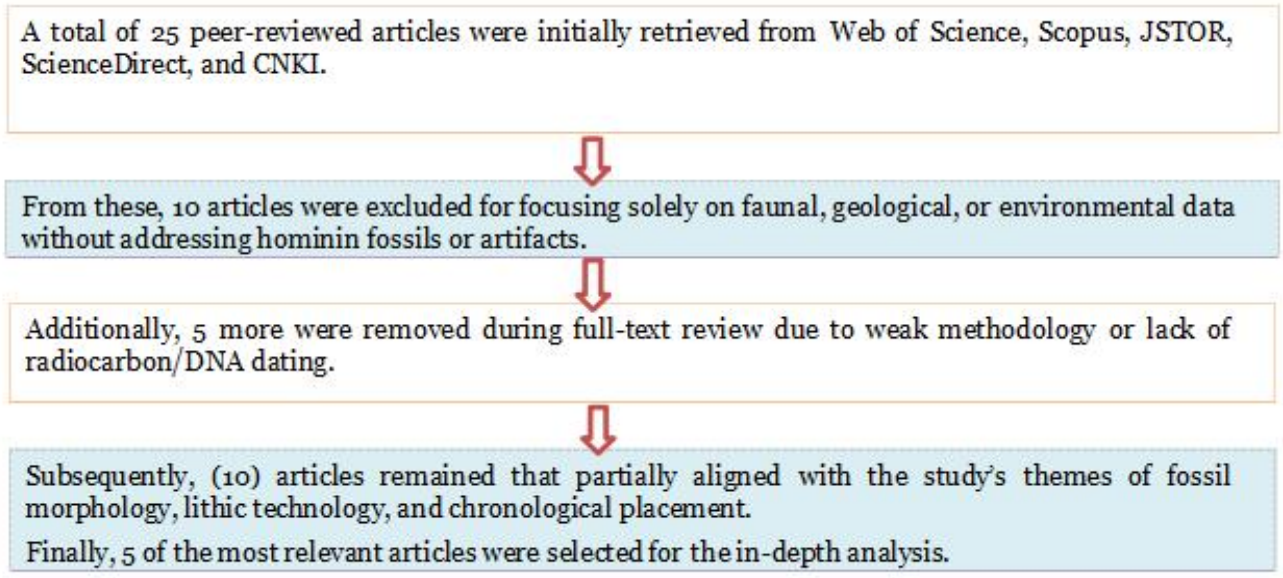

Figure 9. PRISMA Flow Diagram

Table 4. Key Studies, SLR Table

Author(s)	Year	Title	Objective	Keywords	Methodology	Findings
Zhu Hong	1989	Human skulls of Han Dynasty from Zhalainuoer site (the third excavation), Inner Mongolia	To document morphological traits of human skulls from Zhalainuoer Han-Dynasty tombs and compare to regional Mongoloid groups	Zhalainuoer; Han Dynasty; skull; Northern Asiatic Mongoloid	Morphometric analysis of 8 adult skulls, sex & age estimation; comparative morphology with known modern Mongoloid populations	Skulls show chamæcrany and tapeinocrany, wide flat faces; traits match Northern Asiatic Mongoloids; no archaic Homo traits
Ning et al.	2020	Ancient genomes from northern China suggest links between subsistence changes and human migration	To explore how shifts from foraging to farming and herding shaped human migration and population history in northern China	Ancient DNA; northern China	Genome sequencing of 25 ancient individuals (Neolithic–Bronze Age); comparative population genetics; radiocarbon dating	Genetic data reveal continuity mixed with new gene flow; subsistence transitions linked with demographic changes and increased mobility
C. Zhao	2023	Regional variation in the shift towards microlithization: The development of early microblade technology in North China	To trace the emergence and spread of microblade technology and its variation across North China	microblade; North China; cultural transmission; calibrated radiocarbon dates	Lithic analyses; use-wear; radiocarbon calibration; comparative regional assemblages	Early microblade technology emerges around 27-20 cal. ka BP; variation in core types and technique between regions; indicates early adaptation to Late Pleistocene climates
Song et al.	2019	Re-thinking the evolution of microblade technology in East Asia	To reassess when and how microblade technology was adopted, its technological operational sequences, and regional differences	microblade evolution; East Asia; production sequence; technological change	Operational sequence reconstruction; comparative analysis of multiple sites; dating evidence	Microblade technology likely introduced into North China's Loess Plateau earlier than previously thought; regionally patterned differences in technique and raw materials
X. Chen	2023	Radiocarbon dating and its applications in Chinese archaeology: An overview	To review radiocarbon dating methods in China and their applications to prehistoric human occupation, culture, and technology	radiocarbon; AMS; dating; Chinese archaeology; early Homo sapiens	Literature review; methodological critique; charting dated sites; comparison of sample types and dating reliability	Radiocarbon and AMS have greatly improved chronological resolution; many Palaeolithic sites now securely dated; gaps remain in some regions including parts of Inner Mongolia; recommendation for integrating DNA when possible

Theme 1: Fossil Evidence of the Zhalainuoer Hominins

The most direct fossil data from Zhalainuoer derives from Zhu's (1989) analysis of Han Dynasty skulls. These remains show a suite of traits; chamaecrany, tapeinocrany, and wide but flat faces; consistent with the Northern Asiatic Mongoloid cluster. Importantly, they lack archaic features such as thick cranial vaults or pronounced brow ridges. When compared to Middle Pleistocene hominins like Xujiayao or Jinniushan, which exhibit mosaic morphologies combining archaic and derived traits, Zhalainuoer skulls sit firmly within the Holocene spectrum. This indicates that by ~200 BCE–200 CE, the region was already occupied by morphologically modern humans with localized craniofacial variation.

The genomic work of Ning et al. (2020) supports this morphological interpretation. Genomes sequenced from northern China, including individuals labelled ZLNR-1 and ZLNR-2 from the Jalainur/Zhalainuoer area, reveal genetic continuity across the Holocene, coupled with episodes of admixture linked to subsistence transitions. Together, the osteological and genomic evidence highlight that Zhalainuoer documents historical human populations rather than Pleistocene hominins, but still plays a role in reconstructing long-term continuity in Inner Mongolia

Theme 2: Cultural Artifacts and Technological Assemblages

For the cultural/technological theme, the selected literature includes studies of microblades, blades/microblades transition, and subsistence technology in Northeast China. One such study is Blade and microblade industry at Helong Dadong, north-east China, during Marine Isotope Stage 2 (Xu et al. 2024) (ScienceDirect/Cambridge Core). This work provides new radiocarbon dates (ca. 27,300–24,100 BP) for cultural layers containing blade-based tools and microblade technology in the Changbaishan area. The assemblage is heavily obsidian, with refined microblade cores and systematic blade-production techniques. Interactive techniques, such as pressure flaking, are noted. These tool technologies indicate adaptation to cold climatic regimes in MIS 2, and increased mobility and risk buffering in hunter-gatherer subsistence strategies.

Another study by Zhao (2023) adds evidence that microblade technology emerges significantly in northern China during this period, showing regional variation in raw material use, core reduction strategies, and in whether blades are produced as a byproduct vs. purpose-built. Although no lithic artifacts have yet been reported in published excavation data from Zhalainuoer that co-occur with Pleistocene or Late Paleolithic hominins. Thus, artifacts from nearby regions are used as proxies: the lines of technological development seen in Helong Dadong and northern China suggest that had there been continuous occupation at Zhalainuoer in those periods, similar technological assemblages might have been expected.

Subsistence practice is also inferred via wear and environmental proxies in some of the studies. For example, in the microblade-studies, faunal remains and isotopic or zooarchaeological data show that hunters adapted to changing climates by targeting cold-tolerant ungulates, perhaps supplemented with plant foods in warmer seasons. The tools allow for fine butchery, implying meat processing refined for portable subsistence rather than large game alone.

Theme 3: Chronological Placement within East Asian Prehistory

The study Radiocarbon dating and its applications in Chinese archaeology: An overview by Chen, 2023, offers context for dating practice in the region (Frontiers in Earth Science). It confirms that radiocarbon dating (both β-decay counting and AMS) has become standard in Upper Palaeolithic, early Homo sapiens, and Neolithic research in China, and emphasizes that in regions like Hulunbuir (Inner Mongolia), Carbon-14 dating of charcoal, bone collagen, etc., and DNA analyses where preserved, are the principal chronometric methods. (Chen, 2023)

In the Helong Dadong study (Xu et al. 2024), several radiocarbon dates bracket the blade- and microblade-bearing layers at ~27,300–24,100 BP. These dates are considered reliable, with good contexts and charcoal/organic samples associated with cultural layers. (Xu et al., 2024) The study Re-thinking the evolution of microblade technology in North China (Song et al. 2019) (PMC / NCBI) similarly uses calibrated radiocarbon dates to show when microblade technology begins to emerge, anchoring technological transitions in the Late Pleistocene (~30–20 ka BP) periods. (Song et al., 2019) For Zhalainuoer's Han-Dynasty skulls, the dating is non-radiocarbon; they are dated via historical archaeological context (tomb inscriptions, stratigraphy) to the Han Dynasty (~200 BCE - 200 CE). Zhu (1989) does not report Carbon-14 or DNA dating for those remains.

Overall Synthesis

From these five studies, several patterns emerge. First, morphological data from Zhalainuoer, though limited to Han-Dynasty skulls, shows modern human traits with regional variation, and lacks archaic Homo or erectus features, suggesting that if earlier hominins were present, they have not yet been discovered or published in this

area. Second, technological assemblages from nearby Northeast China indicate that blade and microblade industries became well established in the Late Pleistocene (roughly 30-25 ka BP), often associated with colder climatic periods (e.g. MIS 2), involving refined cores, pressure flaking, and use of obsidian. This suggests that human populations in the wider region were responding behaviorally to environmental changes with more mobile, micro-tool technologies.

Third, chronometric evidence supports these technological shifts: radiocarbon dating (including AMS) provides secure dates for microblade assemblages, and offers a framework in which such artifacts may be aligned with climatic phases and human migrations. For Zhalainuoer, the morphological evidence lies in the Holocene / historical period, so direct alignment with Pleistocene phases is not possible, but the historical morphologies provide a point of continuity, and highlight the need for further excavation and dating in Pleistocene layers in Zhalainuoer or its environs.

DISCUSSION

Synthesizing the evidence across four themes clarifies both what Zhalainuoer currently tells us and where new data are most needed. First, the fossil evidence from the locality is securely Holocene in age and morphologically modern, with Han-period crania lacking the robust vaults and supraorbital tori typical of Middle Pleistocene East Asian hominins. In regional perspective, this places Zhalainuoer on the recent end of a broader East Asian mosaic in which late archaic and early modern populations coexisted and interacted over long intervals (Bae & Wu, 2024). Pan-Asian syntheses further underline that northeastern corridors repeatedly channelled dispersals and gene flow during climatic oscillations, producing variability rather than tidy lineages (Sawafuji, Tsutaya, Takahata, Pedersen, & Ishida, 2024). On present evidence, then, Zhalainuoer documents Holocene populations within that longer, spatially complex evolutionary backdrop, while leaving earlier (Pleistocene) occupation unconfirmed.

Second, the cultural–technological theme indicates that if Pleistocene strata are identified in future fieldwork at Zhalainuoer, microblade traditions are the most plausible candidates for discovery. Radiocarbon-anchored assemblages from northeast China (e.g., Helong Dadong) show blade and microblade systems flourishing during MIS 2, with standardized cores and serial blade production that supported high mobility and risk buffering in cold steppe settings (Xu et al., 2024). Region-scale modelling of Paleolithic site distributions across Northeast China also points to punctuated pulses of activity tracking climatic windows, which would be consistent with a microblade signal in any yet-undetected Pleistocene layer around Hulunbuir (Chen et al., 2024).

Third, on chronology, recent redating of hallmark Chinese fossils refines the timeline within which any future Zhalainuoer finds would be situated. The new Late Pleistocene age for the Liujiang Homo sapiens skeleton narrows uncertainty on modern human presence in China and strengthens the scaffolding for correlating northern technologies (e.g., microblades) with population histories (Ge et al., 2024). Together with MIS-2 sequences at Helong Dadong (Xu et al., 2024), this supports a framework in which Zhalainuoer's current Holocene record is a late chapter of a much longer regional narrative rather than an isolated episode.

Finally, the heritage theme remains underdeveloped in scholarship but is strategically important. Zhalainuoer's materials are already embedded in regional identity work through museum curation in Hulunbuir and Zalainuoer, yet interpretive narratives still outpace stratigraphically secure science at this locality. Integrating exhibition claims with rigorous provenience, fine focused dating, and outward open confrontations of uncertainty would enhance both social knowledge and conservation agenda so that heritage value develops in line with increased scientific plausibility. Overall, the discussion recommends three priorities: specific survey of intact Pleistocene sediments around Jalainur; specific chronometry and microblade-centric lithic recovery in case such layers can be discovered; a model of a museum-research relationship that ties interpretation were to testable context. Such measures would shift Zhalainuoer to a location that can test a hypothesis about the region scale, which includes dispersal, adaptations of speciation, and cultural innovation in the north of East Asia.

CONCLUSION

The combination of elements of fossil, cultural, chronological and heritage views emphasize the fact that the Zhalainuoer record in its present state falls squarely in a Holocene architectural, and embodies morphologically modern human populations. Although this is significant to the study of the regional development, the larger history of dispersal, adaptation and interaction in the northern East Asia can only be viewed laterally in this site. Comparative literature does reveal that the northeastern Asian corridors came into repeat participation in

population migration and technological transformation in the Pleistocene especially the proliferation of the microblade systems. Nevertheless, no stratigraphically sound Pleistocene remains are yet established at Zhalainuoer, making it unclear as to its deeper meaning.

Meanwhile, the location already comes with a certain symbolic burden in the history of heritage. The Hulunbuir and Zalainuoer Museums exhibit Zhalainuoer in the accounts about the place and cultural persistence yet would be better served by actual connections with proven scientific data. The clear recognition of uncertainties and increased correlation of research results and presentation to the population would improve precision and increased confidence by the population. Considered as a whole, Zhalainuoer would be better regarded as a late part of the larger East Asian prehistoric series, with all the heritage value that this implies today, and perhaps with an enormous scientific potential in the event that older and undisturbed deposits are discovered and studied by more sophisticated means.

Recommendation

Further work must focus on a progressive research and heritage strategy than starts with noninvasive, regional survey, coring and geoarchaeological mapping of the area around Jalainur and then with a targeted excavation that encompasses strict context control, high precision dating suites including AMS radiocarbon, OSL and U series where appropriate and a recovery plan that is sensitive to small debitage and microblades. In the case of preservation, proteomics and ancient DNA screening protocols ought to be pre-tested. The integration of all field and lab processes with a museum partner to establish shared inventories, provenance tracking, and bilingual public interpretation must be established in such ways that the scientific results and exhibitions grow in tandem. Local involvement of the community and proper data sharing agreements will bolster conservation deliverables. The money should be allocated to a three year plan which includes survey, small scale testing, laboratory results, and refreshing of exhibits, with peer reviewed publications, open digital library, and revised galleries, which better represent the new evidence.

Study Limitation

This research is limited in a number of ways. Zhalainuoer provides evidence which is fragmentary, and much of that is Holocene, and no stratigraphically secure Pleistocene deposits have been established, limiting inferences on evolution. Disturbed contexts that are mined, and lots of primary reports do not provide open datasets lowering reproduction. The review is based on secondary literature and translated Chinese resources, which presents language and selection bias. To maintain depth and restrict breadth only a limited number of high-quality studies were synthesized. Chronometric control at locality is still fragile and no ancient biomolecules have been described and hence taxonomic placement and population history are tentative. There are gaps in museum records and as a result, it is difficult to make provenance connections between collections and publications. The available literature is outdated, most of it is several decades old; dating material is not final, and it is not accurate, which makes it difficult to establish an effective cultural chronology; in addition, the fossil and artifact collections are scattered among various institutions, and the materials have not been collated, which greatly hampers in-depth and continuous research. All these aspects lead to the lack of systematic and definitive conclusions in the given field of research.

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