The Silk Road and the Pan-Third Pole Region: Human Activities, Environmental Change, and the Rise and Fall of Silk Road Civilizations (Post-print)

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Date: 2017-09-20T00:00:00+00:00

Abstract

The Pan-Third Pole region primarily encompasses the Tibetan Plateau and the Asian interior arid region to its north, extending westward to mountain ranges such as the Caucasus and eastward to the western Loess Plateau. Located in the hinterland of the Eurasian continent, this region constituted the main corridor for East-West exchanges during both prehistoric and historical periods. Various ethnic groups and diverse cultures experienced complex and prolonged processes of contact, exchange, conflict, fusion, and sedimentation, thereby opening up convenient channels for East-West civilizational exchange and profoundly influencing the trajectory of human civilization development. Research on human dispersal, human activities, environmental changes, and the rise and fall of Silk Road civilization in the Pan-Third Pole region, as well as their interrelationships, and the analysis of socio-environmental development patterns in this critical area, are of paramount theoretical and practical significance for strengthening historical and cultural identity among nations along the Silk Road and for revealing the natural and social evolution patterns of Silk Road regions. Such research will also provide historical references and decision-making guidance for the construction of the Green Silk Road. The history of human activities, the evolution of civilization, and their interactions with environmental changes in the Pan-Third Pole region should constitute a key research priority for our nation.

Full Text

Preamble

Topic: Progress of Comprehensive Scientific Research on the Tibetan Plateau

Human Activities, Environmental Changes, and the Rise and Decline of Silk Road Civilization in the Pan-Third Pole Region

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Abstract: The Pan-Third Pole region primarily encompasses the Tibetan Plateau and the arid interior of Asia to its north, extending westward to the Caucasus Mountains and eastward to the western Loess Plateau. Situated in the heartland of the Eurasian continent, this region served as a major corridor for East-West exchange throughout prehistory and historical periods. Various ethnic groups and cultures experienced complex and prolonged processes of contact, exchange, conflict, integration, and sedimentation, creating a convenient channel for civilizational interaction between East and West that profoundly influenced the course of human civilization. Investigating human migration, human activities, environmental changes, and the rise and fall of Silk Road civilizations in the Pan-Third Pole region, along with analyzing the socio-environmental development patterns of this critical area, holds significant theoretical and practical importance. Such research not only enhances historical and cultural identity among countries along the Silk Road and reveals the natural and social evolution patterns of this region, but also provides historical references and decision-making support for the construction of a green Silk Road. The history of human activities, civilization evolution, and their interactions with environmental changes in the Pan-Third Pole region should become a key research priority for China.

Keywords: Pan-Third Pole region, human activities, East-West cultural exchange, environmental change, Silk Road

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Introduction: The Pan-Third Pole Region and Its Significance

The Third Pole region refers to the high mountain and plateau area of central Asia centered on the Tibetan Plateau, extending westward to the Pamir and Hindu Kush mountains, eastward to the Hengduan Mountains, northward to the Kunlun and Qilian mountains, and southward to the Himalayas. Covering approximately 5 million square kilometers with an average elevation exceeding 4,000 meters, this region is known as the "Roof of the World," Asia' s water tower, the Earth' s third pole, China' s ecological security barrier, and the core area of the "Belt and Road" initiative as well as a driver of regional climate and environmental changes. The Pan-Third Pole region radiates outward from

the Third Pole in all directions, though primarily expanding east-west, reaching the Caucasus Mountains in the west and the western Loess Plateau in the east, covering over 20 million square kilometers [Figure 1: see original paper] and encompassing more than 3 billion people. This region aligns closely with the "Belt and Road" initiative and represents the birthplace of the world' s four great ancient civilizations.

Located in the Eurasian interior, the Pan-Third Pole region has witnessed human activity since at least the dispersal and development of anatomically modern humans across Eurasia. Through prolonged natural-social-economic development, different ethnic groups and cultures experienced complex, long-term processes of cultural exchange and integration, cultivating this continuous zone where Eurasian culture, religion, politics, and economy intersect and merge. The region not only served as a homeland for early humans but also as a crucial corridor for early population dispersal and cultural exchange. The "Belt and Road" initiative, comprising the Silk Road Economic Belt and the 21st Century Maritime Silk Road, represents China's national strategy under the new international political and economic development pattern and offers new opportunities for Pan-Third Pole region development. In September 2013, Chinese President Xi Jinping first proposed the concept of jointly building a trans-Eurasian "Silk Road Economic Belt" during his visit to four Central Asian countries. This innovative model of large-scale cooperation will revive the glory of Silk Road civilization, bringing significant development opportunities for trade, cultural exchange, social development, and ecological environment construction along the Silk Road countries and China' s western provinces. The Pan-Third Pole region is the core area of the Silk Road Economic Belt and an extremely important ecological barrier. Its resource and environmental conditions hold great significance for the development of China and countries along the Silk Road, while also concerning the realization of China' s "Silk Road Economic Belt" construction goals.

Paleolithic Human Activities in the Pan-Third Pole Region

The Pan-Third Pole region has a long history of human activity and represents one of the earliest areas of human activity in Eurasia outside Africa, serving as an important region for early human dispersal and exchange [Figure 1: see original paper]. The Dmanisi site in Georgia has yielded hominin fossils dating to 1.9 Ma (Ma = million years ago), providing the earliest evidence of *Homo erectus* migrating out of Africa. Java Man in Indonesia represents the earliest record of *Homo erectus* reaching Southeast Asia. The Kuldara site in Tajikistan marks the earliest human footprints in Central Asia. Sites in the Nihewan Basin of northern China (Majuangou, Xiaochangliang, Donggutuo), the Lantian (*Homo erectus* lantianensis) site on the northern side of the Qinling Mountains, and the Yuanmou site in southern China represent the earliest evidence of human activity in East Asia. These findings demonstrate that after leaving Africa, early humans rapidly dispersed across eastern Eurasia, with continuous population

exchange across the vast Eurasian continent, never isolated by the high-altitude Tibetan Plateau, Pamir Mountains, or the arid Central Asian deserts.

During the Late Pleistocene, anatomically modern humans first appeared in East Africa around 100,000 years ago and began dispersing across Eurasia, reaching the Australian continent around 60,000 years ago and the Americas during the Late Pleistocene. By the end of the Pleistocene, modern humans had ascended the "Roof of the World" (Tibetan Plateau) and the "Backbone of South America" (Andes). The Late Pleistocene witnessed increased human activity intensity and more numerous sites in the Pan-Third Pole region and its surroundings, characterized by complex populations and diverse cultures. Compared to Europe, East Asia has fewer human fossil localities but more archaeological sites, generating considerable debate regarding human evolution and dispersal. The Altai region simultaneously hosted Neanderthals and Denisovans, while China had the potentially Neanderthal Xujiayao hominins, the strongly locally-evolved Xuchang hominins, the controversial Zhiren Cave modern humans in Guangxi, the Daoxian modern humans in Hunan, and the Tianyuan Cave modern humans with both morphological and genetic support. These findings indicate that multiple regional populations coexisted in this region during the Late Pleistocene. From a lithic culture perspective, the Altai and Mongolian regions were dominated by Mousterian and blade technologies, while northern China featured traditional small-flake industries, though some sites like Shuidonggou in Ningxia, Humashibazhan in Heihe, and Tongtiandong in Xinjiang also show Western Levallois, Mousterian, and blade technology elements [3,4]. The diversity and complexity of Late Pleistocene populations and cultures in this region make it a major area of controversy in modern human origins and dispersal research. Current discoveries challenge the classic Out-of-Africa hypothesis, leading some Western scholars to speculate that modern humans may have left Africa earlier. Alternatively, Asian *Homo erectus* may have evolved into modern humans during the early Late Pleistocene, migrating southward during cold glacial periods and westward along open forest environments that may have existed during glacial periods, eventually reaching Africa and then migrating out again. Another possibility is that more evolved Asian *Homo erectus* with modern human characteristics dispersed westward to Europe and evolved into early Neanderthals [5]. Only this "Out-of-Asia first, then Out-of-Africa" model can better explain why modern humans leaving Africa could integrate and develop with Neanderthals and local Asian populations. This hypothesis requires more archaeological and genetic evidence and further in-depth research, but whether through an original Out-of-Asia theory or the Out-of-Africa dispersal of modern humans to Eurasia and Australia, both scenarios must confront the influence of the Pan-Third Pole environment and its changes.

The Tibetan Plateau, in particular, holds great significance for studying human adaptation to high-altitude environments. With its extreme elevation, thin oxygen, cold and dry conditions, and relatively monotonous flora and fauna resources, the plateau poses physiological and subsistence challenges to human survival. The process of prehistoric human dispersal onto the Tibetan Plateau

required both physiological and technological adaptation to high-altitude environments. Research shows that prehistoric humans first reached the northeastern Tibetan Plateau around 15,000 years ago, with major sites concentrated in the Qinghai Lake Basin. Human presence in the southern Tibetan Plateau may have occurred relatively later, with the age of the Qiusang site still under considerable debate [6,7]. Before agriculture and animal husbandry reached the plateau in the mid-to-late Holocene, ancient humans subsisted through seasonal hunting and gathering [8] with long-distance, large-scale migrations. However, genetic studies suggest that prehistoric humans may have reached the Tibetan Plateau as early as before the Last Glacial Maximum [9], though related archaeological sites have been questioned due to lack of reliable dating [10]. More systematic archaeological surveys and research on the Tibetan Plateau are crucial for further understanding its ancient human activity history.

Neolithic to Historical Period: Agricultural Revolution and Silk Road Formation

Human production and lifestyle underwent tremendous changes around 10,000 BP (Before Present), with two of the world' s earliest domestication centers emerging on the eastern and western sides of Eurasia [11,12]. Wheat, barley, cattle, and sheep were domesticated in the Fertile Crescent of West Asia, while rice and millet (*Panicum miliaceum* and *Setaria italica*) were domesticated in China' s Yangtze and Yellow River basins, respectively. The agricultural revolution represented one of the most significant technological innovations in human history, transforming humans from mobile hunter-gatherers to sedentary agricultural producers. This resulted in shortened reproductive cycles and increased survival rates, providing stable food sources through crop cultivation and animal husbandry. The agricultural revolution drove rapid population growth in domestication centers, expansion into surrounding areas, and diffusion of technology and culture, playing a crucial role in the overall development of Neolithic-Bronze Age cultures across Eurasia.

One of the most important manifestations of East-West exchange during the Neolithic-Bronze Age was the cross-continental transmission of agricultural elements (crops and livestock), a process also known as prehistoric food globalization [13]. Since crop and animal remains can be dated using radiocarbon methods, summarizing and comparing archaeobotanical data and direct dates of crop remains from prehistoric sites across Eurasia allows us to reconstruct the history of cross-continental cultural exchange. Current results divide prehistoric Eurasian exchange into three main stages [14]: (1) 10,500–4,500 BP, the pre-contact spread and diffusion of East Asian-origin crops (millet) and West Asian-origin crops (wheat, barley), with no clear East-West cultural exchange signals; (2) 4,500–3,500 BP, the earliest convergence of Eastern and Western crops in eastern Central Asia (Kazakhstan and northwestern China) [Figure 2: see original paper], representing the initial stage of cross-continental exchange; (3) 3,500–2,200 BP, the mixed utilization of Eastern and Western

crops had spread to both ends of Eurasia, representing an intensified stage of cross-continental cultural exchange that laid the foundation for the opening of the historical Silk Road.

Beyond agricultural elements, prehistoric East-West cultural exchange left multiple imprints, including painted pottery with Eastern cultural characteristics and bronze artifacts, mace heads, bead ornaments (lapis lazuli, turquoise), and adobe architecture with Western cultural features. Consequently, prehistoric East-West exchange routes are also called the "Painted Pottery Road" and "Jade Road." The rise and diffusion of agricultural and pastoral economies also drove large-scale human migration and diffusion, profoundly influencing modern ethnic and genetic distributions across Eurasia. The emergence and intensification of pastoral economies on the Eurasian steppe during this period likely represented an important factor driving prehistoric East-West cultural exchange and population diffusion [15].

Late prehistoric cross-continental cultural interaction facilitated the formation of the ancient Silk Road in the 2nd century BCE, which became the primary overland channel for East-West cultural exchange during historical periods [Figure 2: see original paper], making important contributions to human civilization development [16]. Academia generally marks Zhang Qian' s mission to the Western Regions in 138 BCE as the opening of the Silk Road, which connected East and Central Asia. Prior to this, Alexander the Great' s empire (356–323 BCE) had already covered vast territories at the western end of the Silk Road [17]. Following Zhang Qian' s mission, a trans-Eurasian communication network was established, linking the development of China with Central Asian, West Asian, and European countries.

The Han Dynasty (202 BCE–220 CE) witnessed the opening and rise of the Silk Road. During the Wei, Jin, and Southern and Northern Dynasties (3rd–5th centuries CE), the Silk Road was intermittently disrupted by political turmoil. While the Roman and Han empires at both ends of Eurasia successively split, ancient kingdoms such as Loulan, Yanqi, and Qiuci emerged in Central Asia, and civilization along the Silk Road continued to develop. During the 6th–9th centuries, relatively humid climate conditions accompanied the rise of the Tang and Arab empires, bringing unprecedented prosperity to ancient civilizations along the Silk Road and reaching the peak of Silk Road development and cross-continental cultural exchange. During the 10th–12th centuries, the southward shift of China' s political, economic, and cultural centers and the development of the Maritime Silk Road gradually reduced the importance of the overland Silk Road. In the 13th century, a relatively wet period contributed to the rise of the Mongol Empire and temporarily revived the overland Silk Road. In 1453 CE, the fall of the Byzantine Empire and its replacement by the Ottoman Empire, which blocked connections between Asia and Europe, became a major event that interrupted cultural exchange between the western Silk Road and China. European countries were forced to seek new maritime trade routes, promoting the Age of Discovery (15th–17th centuries) and the vigorous development of

the Maritime Silk Road. By 1539 CE, frequent border troubles combined with the impact of the Little Ice Age weakened the Ming Dynasty. With the closure of Jiayuguan and the implementation of a "closed-door" policy, cultural exchange along the eastern Silk Road declined, and the traditional Silk Road comprehensively faded [29].

The opening and development of the Silk Road enabled a qualitative leap in long-distance, large-scale cultural exchange across Eurasia, profoundly influencing overall human social development. East-West exchange along the Silk Road was accompanied by the spread of ideas, technologies, religions, and diseases. Chinese silk, lacquerware, tea, and porcelain were transmitted to Central Asia, West Asia, and Europe, while agricultural products (sugar cane, grapes, walnuts), gold and silver ware, spices, and glassware from these regions were introduced to China, significantly impacting production and daily life along the Silk Road. Chinese technological inventions transmitted westward accelerated the development of weapons manufacturing and navigation technology, laying the foundation for new maritime route discovery. The Silk Road also provided convenient channels for religious propagation, including Buddhism, Zoroastrianism, Judaism, and Islam. For instance, Islam entered Central Asia in the 8th century, reached Kashgar in Xinjiang by the early 10th century, and replaced Buddhism as the main religion south of the Tianshan Mountains by the 16th century. Increased exchange in the Pan-Third Pole region also facilitated large-scale disease transmission. In the 14th century, the Black Death outbreak in the Caspian region spread westward to the Arabian Peninsula and Europe, causing Europe to lose one-third of its population. Moreover, the Silk Road served as a route for population diffusion and integration, with historical peoples such as the Wusun, Yuezhi, Xiongnu, Turks, Uyghurs, and Mongols migrating along the Silk Road, substantially altering the spatial distribution of Eurasian populations. Even South Asia' s Mughal Dynasty, the last imperial dynasty of India, claimed Mongol ancestry. In summary, cultural exchange and human activities along the Silk Road have been important drivers of human social development over the past 2,000 years, profoundly influencing current global political and economic patterns.

Environmental Changes in the Pan-Third Pole Region

Long-term Environmental Evolution

Human activities in the Pan-Third Pole region have been deeply influenced by Quaternary environmental changes. Currently, high-resolution environmental evolution sequences for the region come primarily from lacustrine deposits, such as the Caspian Sea, Balikun Lake, and Qinghai Lake. These studies reveal that the Pan-Third Pole environment has undergone substantial changes since the last interglacial period, with clear responses to global changes. Ice core research on the Guliya ice core from the West Kunlun Mountains provides a detailed record of the past 125 ka (ka = thousand years) [20], with its oxygen isotope sequence representing the best temperature change record for the last glacial

cycle in the region. Loess records from Central Asia and Xinjiang have also been published successively.

Paleoclimate research shows that on glacial-interglacial timescales, climate change in the arid interior of Asia was generally consistent with the East Asian monsoon region. For example, the Chashmanigar loess section in southern Tajikistan (38.4°N, 69.8°E) shows that the loess-paleosol sequence over the past 1.77 Ma can be well correlated with sections such as Lingtai (35.0°N, 107.5°E) on China' s Loess Plateau: loess deposition during cold, dry glacial periods and paleosol development during warm, wet interglacial periods, both likely driven by global ice volume changes [21]. Regarding Holocene climate change in the interior arid region, previous research noted differences from the monsoon region, suggesting a "cold-wet/warm-dry" hydrothermal pattern since the last interglacial [22].

Recent improvements in dating precision and reliable proxy indicators have deepened understanding of the unique climate and environmental changes in the interior arid region of Asia. Recent results show that during the last glacial period, both China' s monsoon region and westerly region experienced generally arid conditions [23,24]. Chen et al. [1] integrated 12 high-quality lake records from the interior arid region of Asia, finding that the early Holocene was arid, with most lakes forming only after 7–8 ka BP, while mid-to-late Holocene high lake levels indicated wetter conditions. This result was later supported by a review based on pollen data [25]. Holocene climate and environmental changes in the Central Asian arid region differ from those in the monsoon region, with uniqueness extending beyond opposite hydrothermal configurations to possibly more complex moisture "phase-displaced" patterns.

Recent Xinjiang loess-paleosol records show [26] that the early Holocene was arid with predominant loess accumulation. From 6 ka BP, climate gradually became wetter, developing four paleosol layers indicating relatively humid conditions, with the strongest pedogenesis occurring in the late Holocene. Late Holocene paleosols have even been found in Iran. The humid period in the mid-to-late Holocene had profound impacts on civilization development in the interior of Asia.

Late Quaternary Environmental Change and Current Conditions

From the Late Cretaceous to Late Eocene (126–38 Ma BP), most of the arid central Asian region was occupied by the Tethys Sea and subsequent Paratethys Sea. The Tibetan Plateau and Pamir Mountains had not yet uplifted to their present height and scale. Under a greenhouse climate without polar ice caps, an east-west belt of arid and semi-arid zones existed in central Asia, reflecting arid-semiarid environments controlled by planetary wind systems [18]. By 38 Ma BP, the Paratethys Sea finally withdrew from Central Asia, and the interior Asian arid environment began to form and develop. Based on differences in aridity and distribution, this long-term aridification process can be divided into

three stages: initial aridification, significant intensification, and final formation of the modern arid environment pattern.

During the late Eocene (38–34 Ma BP), the arid environment in Central Asia began to form, intensifying at the Eocene-Oligocene transition. The late Oligocene to early Miocene (26–22 Ma BP) saw further aridification intensification. The Tibetan Plateau and Pamir Mountains had uplifted to considerable scale, with aeolian loess widely developing in the western Loess Plateau [19] and Junggar Basin. During the late Pliocene to Pleistocene (8 Ma BP–2.4 Ma BP), Arctic ice sheets began to develop, with large-scale loess-paleosol sequences developing in the Iranian Loess Plateau in westernmost Central Asia and the Tajik Basin in central Central Asia, while the Taklamakan Desert began large-scale expansion. During the middle and late Pleistocene (1.2–0.6 Ma BP), numerous interior deserts such as the Badain Jaran, Tengger, and Ulan Buh deserts emerged, marking the final formation of the modern arid environmental pattern.

Environmental Change and the Rise and Decline of Silk Road Civilization

The development of the Silk Road experienced different stages. The prehistoric to Han Dynasty period represented the embryonic stage, during which ancient civilizations first emerged in the Mesopotamian region, Indus Valley, and northern China. With cultural diffusion and exchange and improved climate conditions in the late Holocene, cultures in Xinjiang and other areas developed rapidly after 4,000 years ago [27]. The exchange and innovation of agricultural technology ultimately enabled people from the Loess Plateau to permanently settle on the Tibetan Plateau after 3,600 years ago [28]. The emergence of these agro-pastoral settlements laid the foundation for the Silk Road.

The rise and fall of the ancient Silk Road has left rich historical and cultural heritage and provides many useful lessons for "Silk Road Economic Belt" construction, including both successes and profound lessons. For example, Loulan in the Lop Nur region was once an ancient state based on animal husbandry, fishing, and hunting with some agricultural colonization. According to Sima Qian' s *Records of the Grand Historian*, based on Zhang Qian' s experiences: "Loulan produces jade, with abundant reeds, tamarisk, poplar, and white grass; people follow water and grass for animal husbandry." However, when the Tang Dynasty monk Xuanzang returned from his pilgrimage, he observed Loulan as "city walls standing tall, but human habitation cut off." This tragic change resulted from both natural environmental changes and human activities. Investigating the processes of Silk Road civilization rise and decline, social transformation, and environmental changes, along with their interactions from the perspectives of Paleolithic cultures, modern human dispersal, and early agricultural diffusion-induced East-West social development, helps understand the trajectory and patterns of human-environment co-evolution in this region of long human activity and dramatic environmental change. This understanding provides important

historical experience and decision-making foundations for green Silk Road construction, holding significant theoretical and practical importance.

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Note: Figure translations are in progress. See original paper for figures.