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Shield and Spear on the Northern Frontier: The Relationship Between the Yan Great Wall and Iron Artifact Dissemination

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Abstract. This study examines the role of the Yan Great Wall in facilitating ironware diffusion through spatial analysis, archaeological typology, and textual research. Findings reveal that beyond military defense, the Wall propelled iron technology propagation via four pathways: (1) Engineering demand: Large-scale earthwork projects extensively utilized iron hoes (jue) and spades, stimulating production and circulation; (2) Settlement development: Military settlements transformed into civilian towns, fostering stable agricultural communities and iron tool adoption; (3) Border trade: Passes along the Wall facilitated complementary trade between agrarian and nomadic economies, accelerating east-west ironware circulation; (4) Population migration: The Yan court's retreat to Liaodong with artisans leveraged the Wall's protective function for technology transfer. The Yan Great Wall thus constructed a "military-technological-economic" network, serving as a critical conduit diffusing Central Plains iron culture northward and laying foundations for early iron-using societies in Northeast Asia.

Keywords: Yan Great Wall；Technology Transfer；Frontier Development.

1. Introduction

During the Warring States period (475–221 BCE), the state of Yan, as an important vassal state on the northern frontier of the Zhou dynasty, emerged as a significant power amid the intense rivalries among the contending states and secured its place among the "Seven Powers of the Warring States." Under King Zhao of Yan (reigned circa 300 BCE), Yan reached the peak of its national strength. The renowned general Qin Kai crushed the Donghu tribes in the north, expanded Yan's territory through conquest, established five commanderies including Shanggu and Yuyang, and oversaw the construction of the Yan Northern Great Wall. In 214 BCE, during the reign of Qin Shi Huang (the First Emperor of Qin), the systematic integration of the frontier walls constructed by former states such as Yan and Zhao resulted in a continuous and large-scale defensive structure extending from Lintao in the west to Jieshi in the east. This project marked the initial formation of the Great Wall as a unified engineering system, with the the Great Wall of Yan incorporated as a functional segment of this early fortification system.

Yan's position among the contending states during the Warring States period can be attributed to a combination of factors, including the governance policies of King Zhao, the contributions of ministers and generals such as Yue Yi, and the development of advanced productive forces, particularly in iron production and technology, which supported the state's political and military consolidation. Archaeological evidence shows that numerous iron weapons and agricultural tools excavated from the Yanxiadu Capital site reflect advanced smelting and casting techniques and high levels of functional performance for the period. Although existing scholarship on Yan iron artifacts has provided substantial studies on typology and metallurgical technology, the diffusion mechanisms and spatial distribution patterns of these technologies across the state's extensive territory remain insufficiently examined.

The Great Wall of Yan, later integrated into the Great Wall of Qin, functioned not only as an important military fortification and territorial boundary, but also as a cultural symbol that has been recognized across successive generations. As a large-scale engineering project, the construction of the Great Wall undoubtedly exerted a profound influence on material exchange, technological diffusion, and patterns of livelihood in the regions along its course. However, its role as a medium for technological transmission remains insufficiently examined in current scholarship. By comparing the spatial distribution of iron artifacts unearthed within the Yan state with the alignment

of the Great Wall of Yan, this study finds that, apart from the core area of the Yanxiadu Capital site, a significant proportion of these artifacts were discovered in counties located near the Great Wall. This notable spatial correlation raises the question of whether the Great Wall, in addition to serving as a military defensive line, may also have functioned as an important conduit for technological transmission. This study adopts spatial analysis, typological comparison, and documentary research to systematically investigate the role of the the Great Wall of Yan in the diffusion of iron technology. In doing so, it aims to shed light on the complex interactions between military engineering, technological transmission, and regional development in ancient frontier regions.

2. The Spatial Distribution of the Great Wall of Yan and Archaeological Discoveries of Iron Artifacts

Early research on the Great Wall of Yan was primarily based on the analysis of historical texts. According to the Xiongnu Liezhuan ("Account of the Xiongnu") in Sima Qian's Records of the Grand Historian (Shiji). "Yan had a capable general, Qin Kai, who had once served as a hostage among the Hu, and they trusted him deeply. Upon his return, he launched a surprise attack and defeated the Donghu, driving them back over a thousand li. … Yan also built a Great Wall, extending from Zaoyang to Xiangping, and established the commanderies of Shanggu, Yuyang, Youbeiping, Liaoxi, and Liaodong to defend against the Hu." Regarding the location of "Zaoyang" mentioned in the text, scholars such as Wang Guoliang and Zhang Weihua conducted scholarly examinations in attempts to clarify its precise geographical position[1]. Archaeological investigation of the Great Wall of Yan began in 1942, when Li Wenxin first recorded traces of the structure during a regional survey, initiating its formal entry into scholarly discourse[2].In subsequent decades, fieldwork by Yan Zhong, Li Dianfu, and others helped establish a foundational framework for sustained archaeological inquiry into the wall's chronology, structure, and regional impact. Following decades of archaeological investigation and research, scholarly consensus has gradually formed around the basic configuration of the Great Wall of Yan: it is generally recognized to consist of three principal sections—the Northern Outer Line, the Northern Inner Line, and the Southern Line. It is worth noting that the Northern Outer and Northern Inner Lines of the Great Wall of Yan follow roughly similar trajectories. Portions of the Northern Inner Line were later incorporated into the Qin defensive system. Due to centuries of natural erosion and human disturbance, the surviving remains of the wall vary considerably in form: in many areas, the wall itself has largely disappeared, with only barrier fortifications, beacon towers, and scattered segments still extant. Drawing on previous archaeological surveys and scholarly studies, this paper attempts to reconstruct the approximate course of the wall as follows. The general trajectory of the Northern Inner Line of the Great Wall of Yan can be outlined as follows: it begins near Datan, located south of the headwaters of the Luan River and north of Dushikou in present-day Chicheng County, Hebei Province, and extends northeastward[3]. It passes through northern Fengning County and enters Weichang County, running south of Bianqiang Village near the Jiapichuan River, where it crosses the Sheluga River along the mountain ridges[4]. Continuing southeast, the wall enters Yuanbaoshan District in Chifeng City, Inner Mongolia, traverses the Laoha River at an oblique angle, and proceeds into northern Jianping County in Liaoning Province. After exiting Jianping, it re-enters Chifeng City via Aohan Banner (county), then extends across northern Beipiao and Fuxin Mongol Autonomous County[5]. It ultimately crosses the Liao River and terminates just north of the old city of modern-day Liaoyang. During the reign of King Zhao of Yan, the state's power reached its zenith and it continuously expanded its territory northward, resulting in a significant outward shift of the boundaries of its five commanderies. By the late reign of King Wucheng of Yan, the northern boundary of these commanderies had extended more than 350 li beyond its previous furthest point, with even the nearest boundary advancing over 100 li. To guard against incursions by northern nomadic tribes, King Wucheng subsequently constructed an additional outer defensive wall along the northern frontier of the five commanderies. The route of the Northern

Outer Line of the Great Wall of Yan can be traced through the following regions: it begins in the western part of present-day Zhangbei County in Hebei Province and proceeds northward through Taipusi Banner and Zhenglan Banner in Inner Mongolia. It then turns northeastward, crossing Duolun County before re-entering Hebei at Weichang County. Continuing eastward, the wall enters Chifeng City, Inner Mongolia, traverses the Laoha River Basin at an oblique angle, and passes through Aohan Banner and Naiman Banner. It then extends further east across Kulun Banner and into the territory of Fuxin City, Liaoning Province. From there, the route continues through Zhangwu County, Xinmin City, Faku County, and Kaiyuan City. Turning southward, it enters the urban area of Shenyang, bends eastward through Fushun County, and proceeds into the Manchu autonomous counties of Xinbin, Huanren, and Kuandian, ultimately reaching the western bank of the Yalu River[6]. A segment of this wall extends into present-day North Korea, where it is referred to by Korean scholars as the Taeryong River Wall. Based on field surveys and archaeological research conducted by Chinese scholars, this section has been identified as a direct continuation of the Great Wall of Yan constructed during the Warring States period. The North Korean section of the wall runs along the eastern banks of the Taeryong River and its tributaries, the Changsong River and Seongheung Stream Stream. It begins in Chungnam-ri of Pakchon-gun, P'yonganbuk-do, and extends northward through Wonnam-ri (also in Pakchon-gun), Kosŏng-ri (Yŏngbyŏn-gun), Ryonghŭng-ri, Haktang-ri , Tŏkhwa-ri , Pungnim-ri, and Yangji-ri (all in T'aech'ŏn-gun). It then passes through Hakpong-ri, Haksong-ri, Pongryong-ri, and Haksŏng-ri (in Tongch'ang-gun), ultimately reaching Sinan-ri, also in Tongch'ang-gun[7]. In the southern part of Yan's territory, another line of fortifications was constructed, historically known as the "Southern Great Wall of Yan," or alternatively as the "Yi River Great Wall." The background and defensive purpose of this fortification are well attested in historical sources. For instance, in the Strategies of the Warring States (Zhanguo Ce), in the first chapter of the "Yan Strategies," Zhang Yi, while advising King Zhao of Yan, remarked: "If Your Majesty does not ally with Qin... then the Yi River and the Great Wall will no longer belong to you."[8] The "Great Wall" mentioned here refers to the Yi River Great Wall, played a critical strategic role as a defensive barrier against the state of Zhao and as a protective line for the southern frontier and the Yanxiadu Capital. The Southern Great Wall of Yan followed a general eastward trajectory beginning at the foot of Langwojianshan Mountain, southwest of present-day Yixian County in Hebei Province. It roughly traced the course of the southern Yishui River, passing through present-day Xushui District and into the Xiong'an New Area (crossing the counties of Rongcheng, Anxin, and Xiongxian in sequence). Continuing eastward through Wen'an County in Langfang City, the wall terminates near present-day Dacheng County. The preserved remains of this section extend approximately 260 kilometers in length [9].Although Yan was not among the most powerful states in terms of overall strength during the Warring States period, its ironworking technology was notably advanced. As a hallmark of the era's productive capacity, the development of sophisticated smelting and forging techniques—together with the widespread use of iron tools and weapons—played a significant role in supporting Yan's rise to the ranks of the Seven Warring States. Archaeological findings provide empirical support for this assessment: metallurgical analyses of iron artifacts unearthed from the Yanxiadu Capital site indicate that Yan artisans had already mastered techniques such as the decarburization of cast iron and carburization-based steelmaking, enabling them to adjust the properties of iron tools and weapons according to functional requirements [10]. Notably, the discovery of a complete quench-hardened steel sword at the site has pushed back the earliest reliable physical evidence of quenching technology in China by approximately two centuries [11] The Yanxiadu Capital site exhibits a clearly organized spatial layout, comprising a palatial complex, a zone of handicraft workshops (including ironworking facilities), and a residential district for commoners. This functional division reflects a relatively sophisticated system of state oversight and organization of artisanal production. Iron artifacts from the Yan state have been discovered across a wide area, with notable concentrations in the following regions.

Hebei Province: Yanxiadu (Yixian County), Fujiang gou site (Xinglong County), Inner Mongolia: Shabayingzi fortress site (Naiman Banner), Laohushan site (Aohan Banner).

For further details, see the Table 1

Province/Region	Excavation Site	Type and Quantity of Artifacts	Chronological Attribution
Hebei Province	No. 44 Tomb, Yanxiadu Capital, Yixian County	1 iron helmet, 3 iron swords, 5 iron spears, 2 iron halberds, 4 iron knives, etc. (52 items total)	Late Warring States Period
	Fujian'gou Site, Xinglong County	87 iron molds (24 hoe molds, 30 pickaxe molds, 11 axe molds, etc.)	Middle to Late Warring States
Inner Mongolia	Laohushan Site, Aohan Banner	7 iron hoes, 12 iron pickaxes, 3 iron spades, 9 iron sickles, 5 slicing knives, 3 iron chisels, over 600 iron billets	Middle to Late Warring States
	Shabayingzi Fortress, Naiman Banner	4 iron pickaxes, 3 iron hoes, 2 iron adzes, 1 iron sickle	Middle to Late Warring States
	Baihushan / Beitaizi / Zaoshanliang, Banner	5 iron pickaxes	Warring States to Han Dynasty
	Aobaoshan / Chengzishan, Yuanbaoshan District, Chifeng	1 iron cauldron, 2 iron pickaxes	Warring States to Han Dynasty
	Sidaowan Site, Aohan Banner	1 iron spade, 2 iron pickaxes	Middle to Late Warring States
Liaoning Province	Yingfengge Fort, Shangjiahe Town, Xinbin County	1 iron pickaxe	Warring States to Han Dynasty
	Shangjiahe Town, Xinbin County	1 fragment of an iron pickaxe	Warring States to Han Dynasty
	Qiutai Ancient City, Xintai Town, Tieling	3 iron pickaxes, 2 iron spades, 1 iron shovel	Warring States to Han Dynasty
	Lianhuapu Site, Fushun	12 iron pickaxes, 5 iron axes, 8 iron hoes, 7 iron sickles, 9 slicing knives (approx. 80 items total)	Warring States to Han Dynasty
	Yangcaozhuang Site, Anshan	3 iron spades, 2 iron shovels, 4 iron hoes, 6 iron pickaxes, 3 iron sickles	Late Warring States
	Choushuidong Site, Huanren County	1 slicing knife, 1 iron knife, 1 iron planer, 4 iron arrowheads	Warring States to Han Dynasty
	Xiaohuanggou Site, Huanren County	1 iron pickaxe, 2 iron arrowheads	Warring States to Han Dynasty
	Liming Site, Kuandian County	2 iron pickaxes, 7 slicing knives	Middle to Late Warring States
	Daniwa Site, Jinzhou City	2 iron sickles, 1 iron	Middle to Late

	adze	Warring States
Wujintang Site, Huludao City	1 iron pickaxe	Middle to Late Warring States
Yingpan Site, Suizhong County	1 iron ring	Late Warring States
Karachin River East Site, Jianping County	3 iron pickaxes, 1 iron axe	Middle to Late Warring States
Anzhangzi Fortress, Lingyuan City	2 iron adzes, 1 iron shovel, 1 iron axe, 15 iron armor plates, 9 iron arrowheads	Warring States Period
Houmuchengyi, Lüshunkou District, Dalian	1 iron sickle, 1 unidentified iron fragment	ca. Late Warring States–Han Dyn.
Laotieshan, Lüshunkou District, Dalian	3 iron arrowheads, 1 iron knife	Warring States to Han Dynasty

Table 1. Spatial Distribution of Iron Artifact Finds across the Yan State

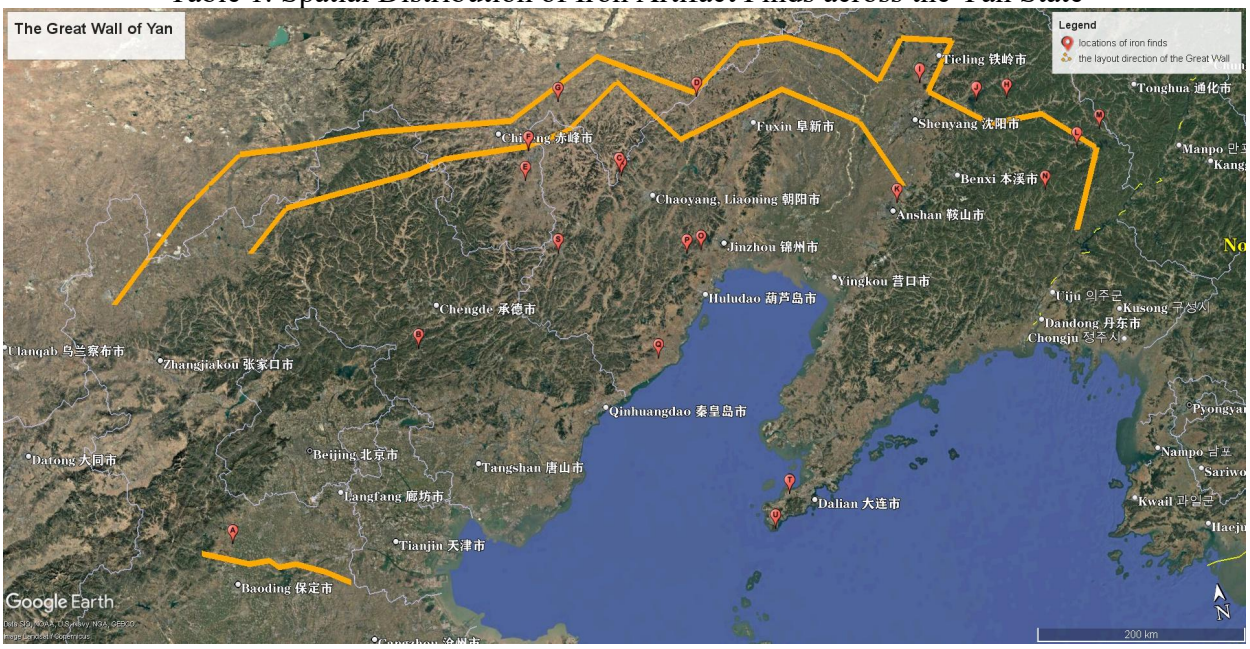

Figure 1. Schematic Map of the Alignment of the Great Wall of Yan.
（Map based on Google Earth, annotated by the author.）

A prominent feature of the spatial distribution of Yan-state iron artifacts is their strong correlation with the route of the Great Wall of Yan, beyond the core ironworking center at the Yanxiadu Capital. This spatial association is particularly evident in the Aohan region, where the inner and outer northern lines of the wall converge—sites such as Laohushan, Shabayingzi, and Sidaowan provide compelling evidence. This can be clearly seen from the map below.

This pattern raises a key question: what role did the Great Wall of Yan and its associated military infrastructure play in the diffusion of iron technology? Section II of this paper explores this question in greater detail.

3. The Concrete Impact of the Great Wall of Yan on the Distribution of Iron Artifacts

3.1 Engineering Demand as a Driving Force

The structural configuration of the Great Wall of Yan integrates three primary components: positioned fortifications leveraging natural topography, stone masonry walls, and rammed-earth walls. Among these, the rammed-earth walls—commonly known in folk terminology as the "earthen dragon"—were the most massive, typically constructed using locally sourced soil and compacted through the banzhu (formwork ramming) technique. During the construction process, large-scale earth-moving operations functioned as the foundational yet labor-intensive core phase. Consequently, the typology and operational efficiency of soil-excavation tools emerged as critical determinants of project feasibility.

During the Warring States period, "the affairs of state lie in sacrifices and war." Bronze, as a strategic material, was monopolized by the upper class due to its scarcity. It was primarily used to cast ritual vessels, weapons, and symbolic funerary objects, rarely being employed for the production of agricultural tools. This was primarily due to two factors:

1. Value Orientation: Bronze was revered as "fine metal" (meijin). Its precious nature contradicted the high-wear characteristics of farming tools.

2. Economic Cost: As argued by Yang Chong in A Preliminary Study on the Prevalence of Bronze Farming Tools in the Western Zhou Dynasty, even when bronze tools occasionally appeared on aristocratic estates, their prohibitive cost prevented widespread adoption [12].

Against this backdrop, farming tools long relied on non-metallic materials such as bone, wood, and stone. However, the Yan state — a technologically advanced major power with pioneering iron-smelting techniques — provided the means to break through this constraint through its mature iron production chain. Owing to its relative abundance, superior mechanical strength, and excellent malleability, iron emerged as an ideal alternative to traditional materials, significantly enhancing the efficiency of construction and engineering activities. Therefore, the large-scale use of iron agricultural tools — particularly earth-working implements such as hoes, Iron chǎ spade, and shovels—in the earthwork construction of the Great Wall of Yan appears to be historically well-founded. Taken together, the dissemination and application of iron tools, especially iron agricultural implements, exhibited a profound symbiotic relationship with the construction of the Great Wall of Yan.

The construction of the Great Wall itself functioned as a major driving force behind the dissemination of iron tools across the northern frontier. The building of the Wall was not only enabled by iron technology but also contributed to its wider spread. For example, an iron chisel unearthed in Aohan Banner—likely unrelated to agricultural production—may have been used specifically in wall construction. Moreover, the numerous iron hoes recovered from the region could have served dual purposes, functioning in both agricultural activities and construction work. The earthen ramparts of the Great Wall of Yan were constructed using the traditional banzhu (formwork ramming) technique, which required the intensive mobilization of soil resources. As one of the most commonly used and effective tools for earth excavation during the period, the iron hoe—originally designed for agricultural purposes—was likely also employed in large-scale construction activities such as wall building. It is therefore reasonable to infer that iron hoes served a dual function in both agriculture and military engineering.

From a climatic perspective, Zhu Kezhen, in his foundational work on China's paleoclimate titled Preliminary Study on Climate Change in China over the Past Five Thousand Years, pointed out: "The Twenty-Four Solar Terms were established during the Warring States period based on climatic observations in the Yellow River basin. At that time, the term Shuangjiang (Frost Descent) was set around October 24 in the solar calendar. Today, the first frost in the Kaifeng–Luoyang

region typically occurs between November 3 and 5. The term Yushui (Rain Water) was fixed on February 21 during the Warring States, whereas the last frost in the same region now generally falls around March 22. Judging from this, the current growing season is 30 to 40 days longer than it was during the Warring States period. This indicates that the climate at that time was significantly warmer than it is today." [13]The climate during the Warring States period was considerably warmer than that of the 1970s. As a result, even in the northern regions such as the state of Yan, the number of days when the ground was frozen would have been relatively limited. This climatic condition further supports the plausibility of using iron hoes as effective earth-working tools in the construction of the Great Wall.

Taken together, the construction of the Great Wall of Yan served as a critical driving force in the dissemination and practical application of iron tools—particularly agricultural implements—across the northern frontier. This impetus operated on two primary levels.

First, tool demand stimulated both production and distribution. The massive scale of the wall-building project, especially the earthen sections constructed using the banzhu (formwork ramming) technique, required the excavation and transport of enormous volumes of soil. This, in turn, generated a substantial demand for efficient earth-working tools. As the most advanced implements for such tasks at the time, iron hoes — alongside iron spades and Iron chǎ spade—naturally became the tools of choice. Their use was not confined to agricultural production, but extended broadly into major civil engineering works, including the construction of fortifications and defensive walls.

Second, archaeological findings provide strong material evidence for this interpretation. For instance, an iron chisel unearthed in Aohan Banner, though not a typical farming tool, may have been used for shaping wooden components or finishing stonework in wall construction. Even more prevalent are the numerous iron hoes recovered from northern frontier sites; their functions should not be narrowly attributed to agricultural use alone. Given the immense scale of the earthworks involved in constructing the Wall, it is highly plausible that iron hoes were produced or requisitioned in large quantities specifically for this type of labor.

Moreover, paleoclimatic research by Zhu Kezhen indicates that the Warring States period was significantly warmer than the 1970s, resulting in a shorter annual period of ground freezing in northern regions such as Yan. This would have provided more workable days for earth-moving operations, thereby enhancing the climatic feasibility and operational practicality of using iron tools—particularly iron hoes—in the large-scale construction of rammed-earth fortifications like the Great Wall.Bulleted lists look like this:

3.2 Settlement Growth: A Factor in Iron Spread

After Qin Kai established five commanderies and initiated the construction of the Great Wall, the military stability provided by this defensive system exerted a significant impact on the regions south of the Wall that originally belonged to the state of Yan. Under the relatively secure border environment, local inhabitants along the Wall were able to develop stable settlements, gradually forming urban agglomerations. Survey data by Li Shulin revealed numerous city sites. distributed along the Wall, including several large-scale sites such as Gaoershan City in Fushun, the ancient city of Shangbaiguantun in Shenyang, and Qiutai Ancient City in Xintaizi Town, Tieling. Yan Zhong's research further indicates that small cities in Yan were even more numerous, with over a hundred sites identified near the northern Yan Great Wall alone [14]. Examples include archaeological discoveries like the Dongshanzui Ancient City and Aobaoshan City within Chengde, Hebei Province. The guarantee of a secure environment was a prerequisite for the sustained development of agricultural production, which in turn promoted the dissemination and application of iron agricultural tools such as iron hoes and iron sickles within the region.

Regarding the developmental pattern along the Wall, American scholar Gaubatz proposed a core argument: "The urban-rural development model in the Great Wall zone is characterized by towns preceding rural areas, towns outweighing rural regions, and towns being supported more by

commerce than by agriculture. The significance of towns lies not in their scale but in their function. Due to the need for garrison troops to engage in production for self-sufficiency, the functional transformation from military towns to civilian towns became a widespread phenomenon. Many garrison towns even possessed some civilian functions before formal transformation was initiated" [15].

The Great Wall and the border commandery cities or frontier towns along its route essentially formed an interdependent and symbiotic system with three main characteristics:

1. Functional interdependence: Frontier towns provided essential daily supplies and logistical support for the troops guarding the Wall, while the Wall functioned as the core military barrier safeguarding the security of these towns and the state's hinterland.

2. Multifunctionality: These towns served not only as military strongholds but also housed personnel responsible for defense, grain storage, military coordination, administrative management, transportation hubs, commercial trade, financial services, and handicraft production, reflecting a complex social and economic role.

3. Mutual support: Towns continuously supplied manpower, material resources, and organizational support for the construction, maintenance, and operation of the Great Wall. Conversely, the Wall effectively curtailed nomadic incursions from the north, substantially reducing the risk of disruption to frontier towns and their inhabitants, thereby providing the necessary security guarantee for internal socio-economic activities.

3.3 Frontier Trade-Driven Iron Spread

The military barrier function of the northern section of the Great Wall of Yan created a relatively stable environment for trade along the frontier. Based on the economic complementarity between the agrarian civilization of Yan and the handicraft- and pastoral-oriented economies of neighboring nomadic and semi-nomadic groups—such as the Donghu and Yemaek—an institutionalized system of cross-border trade gradually emerged at key passes along the Wall. These regulated exchanges facilitated the flow of agricultural products, livestock, and artisanal goods, embedding frontier commerce within a broader framework of military security and interregional interaction. This process not only accelerated the east–west diffusion of materials such as ironware along the axis of the Great Wall—extending from Liaodong to the Korean Peninsula—but also promoted the circulation of goods across the northern and southern zones of the Wall. The discovery of numerous coins from the states of Han, Wei, Zhao, Qi, and Qin across various regions of Yan indicates that frequent commercial and monetary exchanges took place between Yan and these neighboring polities. Markets (shi) were established in the Yan capital as well as in other major urban centers. Historical records note that a market, known as the Yan Market (Yanshi), was located north of the palace complex in Ji, the capital city of Yan. In addition, numerous cities were distributed along the route of the Great Wall of Yan, many of which developed their own local markets, often emerging spontaneously within urban settlements. As essential tools of production, iron agricultural implements were widely traded both within and beyond the boundaries of commanderies and counties. In the area adjacent to the northern segment of the Great Wall of Yan alone, over a hundred cities and towns of various sizes have been identified, many of which were established in direct relation to the Wall. The presence of the Wall not only ensured regional security but also contributed significantly to the economic vitality and commercial prosperity of these urban settlements. As recorded in the Guanzi, chapter "Qingzhong II", "When agricultural activities are about to commence, farmers are organized in groups of ten or five to mutually guarantee each other, and iron ploughshares are allocated to them in advance; this is referred to as the timely season of spring" [16]. This passage reveals that the sale and distribution of iron agricultural tools were common practices at the beginning of the farming season, often involving collective responsibility within farmer groups. However, instances of iron tools being traded beyond the borders of the state of Yan are relatively rare. This suggests that while iron implements were readily available and

frequently exchanged within Yan's urban markets, the passes along the Great Wall of Yan likely functioned as barriers, restricting the outward trade of ironware into neighboring regions.

3.4 Demographic Mobility and Technological Diffusion

After Jing Ke's failed assassination attempt on the Qin king in 227 BCE, the Qin general Wang Jian led his forces west of the Yi River to defeat the allied armies of Yan and Dai. In the following winter (226 BCE), Qin troops captured Ji City, the capital of Yan (present-day Beijing), forcing King Xi of Yan, Crown Prince Dan, along with members of the royal family, elite troops, and skilled artisans, to flee eastward to Liaodong Commandery. The remnants of Yan's forces were able to regroup and recover in Liaodong for about four years. This was partly due to the Qin army's temporary diversion southward to conduct the campaign against Chu, and partly because of the sustained military barrier provided by the northern Great Wall of Yan, which effectively resisted incursions by northern nomadic tribes and ensured the safe migration of the exiled group[17].The eastward relocation of the royal family and elite groups represented a crucial episode of technological transfer. Although the state's overall power had declined compared to its former strength, it still maintained significant influence in the frontier region of Liaodong. The migrating contingent included not only political leaders and military forces but also skilled artisans proficient in advanced techniques, along with a considerable cache of iron weapons and tools. This movement objectively facilitated the dissemination of iron technology from Yan's core centers, such as Yanxiadu Capital, to Liaodong's borderlands. The routes and impacts of iron technology dissemination described above have been corroborated by archaeological evidence. Within the broader sphere of influence of Liaodong Commandery—such as in northern parts of the Korean Peninsula and at the Erlong Lake Ancient City site in present-day Jilin—iron artifacts have been unearthed that exhibit striking morphological similarities to those from Yanxiadu Capital. These findings strongly support the conclusion that Yan systematically transmitted its advanced iron culture to the northeastern frontier and adjacent regions through multiple mechanisms: military expansion (e.g., Qin Kai's eastern campaigns), administrative integration (e.g., the establishment of Liaodong Commandery), and the later migration of population elites (e.g., King Xi's flight to the east).

Iron smelting and manufacturing technologies during the Warring States period were highly sophisticated core crafts, the knowledge of which was far beyond the reach of ordinary artisans. These techniques were typically monopolized by specialized artisan groups under direct state control. Against this backdrop, the retreat of King Xi of Yan to Liaodong Commandery in 226 BCE holds particular significance in the context of technological transmission. As the final stronghold of Yan's residual regime, Liaodong Commandery became the refuge of the state's political core—including King Xi and his entourage of elites—who likely brought with them both skilled artisan groups possessing core ironworking technologies and the associated means of production. Although Yan was already in terminal decline, the administrative infrastructure of Liaodong Commandery, combined with the continued defensive function of the Great Wall of Yan in the north, temporarily held off Qin pursuit and incursions by northern nomadic forces. This created a crucial buffer that enabled the survival and preservation of the exiled regime and its technological assets.

At this stage, the Great Wall of Yan served as an effective barrier against steppe military groups, protecting the personal safety of the royal family, military forces, and artisan communities within Liaodong Commandery. Indirectly, it also created favorable conditions for the diffusion of ironworking technology in the region.

3.5 Conflict-Driven Dissemination of Iron Technology

During the Warring States period, the northern frontier of the Yan state lay within an ecological transition zone between agrarian and nomadic civilizations. The persistent military conflicts and economic complementarities in this region significantly facilitated the bidirectional diffusion of

both material culture and technological knowledge. In addition to its confrontations with northern nomadic groups, Yan also engaged in frequent warfare with neighboring states such as Zhao and Qi. As a major defensive infrastructure against Zhao and Qi, the construction of the southern section of the Great Wall of Yan played a role in containing the scale of these conflicts.

Even when conflict was inevitable, the Great Wall still functioned as a clear demarcation of territorial authority, thereby creating specific conditions for the transmission of military technologies such as iron weaponry.

During military conflicts, the mutual seizure of weaponry between belligerent states was virtually unavoidable, and such acts of appropriation constituted a key mechanism for the circulation of both material culture and technical knowledge. For instance, in the seventh year of King Wucheng of Yan (265 BCE), a war erupted between Yan and Zhao. According to the Shiji (Records of the Grand Historian), specifically the “House of Shao Gong of Yan” and the “House of Zhao,” the Qi general Tian Dan launched a campaign against Yan and captured Zhongyang. Subsequently, in the second year of King Xiaowang of Yan (256 BCE), Yan exploited the intensifying hostilities between Qin and Zhao—during which Qin general Jiao reportedly seized more than twenty Zhao counties and took ninety thousand prisoners, while Zhao generals Le Cheng and Qing She repelled and routed the army of Qin general Xin Liang—to mount another offensive against Zhao, capturing Changzhuang in the fifth month. These episodes of sustained frontier conflict and siege warfare along the Great Wall not only escalated military confrontations among Yan, Zhao, and Qi, but also served as conduits for the regional transmission and cross-fertilization of advanced iron weapon production technologies, primarily through the appropriation of war spoils.

3.6 Transboundary Ethnic group Continuities

During the mid to late Warring States period, in addition to the Huaxia ethnic groups, several minority groups such as the Donghu and Yemaek remained active within the territory of Yan. Notably, the Liaodong region had long served as a traditional settlement area for the Yemaek people. In the late reign of King Zhao of Yan, the state expanded its territory by annexing the “Maek State,” located in the vicinity of the Chagang-do region of the Korean Peninsula. Thus, the construction of the Yanbei Great Wall politically fragmented the Yemaek people: although both groups resided within Liaodong Commandery, the wall physically divided the Liaodong Maek. By the Han Dynasty, the Maek populations separated by the wall had evolved into two distinct tribes—the Yangmaek and the Sosumaek[18]. Although evolving into two distinct tribes, the artificially imposed border demarcation did not sever the Yemaek people's ethnic consciousness or cultural bonds. Conversely, precisely because of their shared lineage and ancestral ties, Yemaek communities across the Great Wall inherently maintained the impetus for cross-boundary material exchange Compared to the Yan rulers' stringent control over frontier trade, the Yemaek people more proactively engaged in cross-regional material exchange through strategic nodes like Great Wall passes and river valleys. This activity was driven by their kinship networks and subsistence needs. Such exchanges proved exceptionally efficient due to inherent intra-ethnic trust, ultimately transforming the Great Wall into a functional conduit for ethnic economic interaction rather than an impermeable barrier.

3.7 Iron Diffusion via Wall-Adjacent Corridors

The Great Wall itself functioned as a longitudinal transportation corridor across the frontier. During its construction, the Yan state was compelled to develop transportation routes along the wall in response to the immense logistical demands of mobilizing labor and materials. Based on the scale of later Qin dynasty projects that followed the earlier foundations laid by Yan and Zhao, it can be inferred that the transport of grain alone for a labor force numbering in the hundreds of thousands would have required over a million cart trips annually. Such an undertaking would have necessitated the establishment of an extensive east–west road network that connected the frontier

with the interior. Archaeological evidence indicates that the top of the Great Wall of Yan featured a roadway, while a patrol path ran along its base—together forming an east–west arterial route. In addition, north–south passages passing through the wall's gateways served to connect the regions on either side of the frontier[19] .This infrastructure not only served military defense purposes but also functioned as a core conduit for the northward transmission of iron tools into pastoral zones and the southward movement of animal products, such as hides and furs, into agrarian regions. At the level of engineering, it laid the physical foundation for sustained material and cultural exchange across the frontier.

4. Conclusions

The Great Wall of Yan, as a pivotal defensive infrastructure in the northern frontier during the Warring States period, transcended its primary military function to serve as a polyvalent vector for iron technology dissemination. The construction of this fortification system propelled the application and dissemination of iron technology. Relative frontier stability fostered agricultural and settlement development, expanding civilian iron usage; transport nodes intensified material circulation, creating conduits for iron diffusion; while inter-ethnic interactions and wartime migrations further extended iron's technological footprint. Functioning as a crucial conduit, the Great Wall of Yan mediated political-military-economic-technological synergies that channeled iron innovations from the Central Plains northward, constituting an indispensable vector in the formation and evolution of early Iron Age cultures across northern China.

By constructing the Great Wall of Yan, the Yan state established not merely a frontier defense system, but more significantly, a conduit for technological diffusion. Iron implements proliferated through garrison fortifications, settlement expansion, frontier markets, and inter-ethnic exchange, revealing the symbiotic relationship between military engineering, production technologies, and territorial development. This study preliminarily uncovers multiplex mechanisms governing technological flows in ancient borderlands, while offering a nuanced perspective on the dialectic between megaproject construction and associated technology dissemination. Given the paucity of Warring States textual evidence and the limited corpus of excavated iron artifacts from Yan territories, further evidentiary support for iron technology transmission chains awaits future archaeological investigation.

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