



THE ARCHAEOLOGICAL VALUE OF ARROWS AND CROSSBOWS IN THE TANG DYNASTY AND ITS INFLUENCE ON THE STUDY OF MODERN COLD WEAPONS

Zhijiang Yu ¹, Fei Wang ^{2*}

¹ Assistant Professor/Ph.D, Higher Vocational and Technical College, Henan Institute of Science and Technology, Xinxiang, China

² Associate Professor/Master, Ministry of Sports, Xiamen Institute of Technology, Xiamen, China

* **Corresponding Author:** wangfei19830719@126.com

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ABSTRACT

In order to excavate the archaeological value of cold weapons, the arrows and crossbows of the Tang Dynasty are taken as the research object. The metal material, external shape and oxide of the crossbow were observed by microscope, the internal composition of the crossbow was observed by infrared imager, and the mass distribution and other indicators were observed by the mechanical measuring instrument, and the research was carried out in combination with the network literature. The results show that the crossbow of the Tang Dynasty is mainly bronze, containing a small amount of lead, tin and other metals, with a surface hardness of 2.3~4.2Hb, and oxides such as lead oxide and iron oxide. Therefore, the Tang Dynasty arrow crossbow has the rationality of pneumatics and gravity in the design of arrows, and the content of tin, lead and other materials is reasonable, which has practical value, and promotes the development of modern cold weapon forging and pneumatic layout.

Keywords: Tang Dynasty, Arrows and Crossbows, Cold Weapons, Modern Cold Weapons Research.

INTRODUCTION

During the Tang Dynasty (618-907 AD), the crossbow was a very important cold weapon, which had the characteristics of long-range precision shooting and long range, accurate strike, and great shock and power. Arrow crossbows have existed since ancient times, and can be traced back to the Spring and Autumn Period and the Warring States Period, however, during the Spring and Autumn Period and the Warring States Period, the development of arrow crossbows was far less than that of the Tang Dynasty (618-907 AD). Its shooting accuracy and range, quantity, manufacturing process and technology, etc., have many deficiencies. With the passage of time, the original arrow crossbow was fully improved and innovated, resulting in a more advanced arrow crossbow in the Tang Dynasty. Historically, the classification of crossbows in the Tang Dynasty increased, including light crossbows and heavy crossbows, among which the Tang Dynasty army widely used heavy crossbows to gain advantages in warfare and obtain higher range and accuracy (Anooshahr, 2020; Böhm, 2021). From a technical point of view, the technical improvement and optimization of the Tang Dynasty arrow crossbow can be described as very successful, for example, compared with the arrow crossbow in the Han Dynasty, the Tang Dynasty arrow crossbow has a more precise structure, and at the same time, it is also equipped with more advanced aiming devices and arrow crossbows. Improvements to make the Tang Dynasty Arrow Crossbow perform better on the battlefield (Apendiyev & Satov, 2020; Bossler, 2020). As a common cold weapon in the Tang Dynasty military, the arrow crossbow played a strong role in many wars in the Tang Dynasty, and had a profound and long-term impact on the design of modern cold weapons. The Tang Dynasty arrow crossbow was manufactured with exquisite craftsmanship and efficient shooting effect, and at the same time, it could be used with a variety of flexible tactics to improve the combat effect of cold weapons. As a kind of cold weapon, the

crossbow in the Tang Dynasty was a very lethal long-range weapon in ancient Chinese warfare, which could exert great military influence. The function of the crossbow is to hold the arrow in place and maintain a steady flight. During the Tang Dynasty (618-907 AD), the components of the arrow crossbow also included the arrow crossbow. First, the crossbow can hold the arrows in place (Candelora, 2021; Karamursel, 2023). It is usually used to place arrows, and when the arrows are fixed to the crossbow, the archer can then pull the string to hold the arrows to the crossbow. This design ensures that the arrow does not break away from the bowstring when the shooter shoots, ensuring the accuracy and stability of the shooting process. Secondly, the crossbow can keep the arrows flying steadily. For example, it can use the role of a stable support point to keep the arrow flying in a straight line after shooting, so that the arrow will not shake and deviate, to achieve the purpose of accurate shooting. Moreover, in the process of development, it is also constantly evolving, from a simple structure to a more sophisticated structure, and through technical perfection, to reach a better peak of cold weapon development (Chen et al., 2022; Li, 2023). This has a great impact on the design and manufacture of modern cold weapons in China. The excavation of the archaeological value of the arrow crossbow in the Tang Dynasty is of great practical significance. Therefore, this paper focuses on the archaeological value of crossbows in the Tang Dynasty, to better understand the components and manufacturing of crossbows in the Tang Dynasty, the development history, and the characteristics of each stage of development of crossbows in the Tang Dynasty. The archaeological value of the arrow crossbow in the Tang Dynasty is excavated in depth, and the development history of its military application at that time is briefly discussed. To study the influence of crossbows on modern cold weapon research. The purpose of this paper is to explore the role and influence of crossbows in the battlefield during the Tang Dynasty, and to understand the military application value and manufacturing process of crossbows in the Tang Dynasty. By analyzing the composition and function of the crossbow in the Tang Dynasty and the ingenuity in the tactical application, this paper reveals the long-range strike advantage, flexible maneuverability, and continuous suppression ability of the crossbow in the Tang Dynasty, and explores its influence on the research of modern cold weapons. Based on this, we can better understand the military value of traditional cold weapons. Therefore, as a very important long-range shooting cold weapon in the Tang Dynasty, the crossbow was well used in the Tang Dynasty (618-907 AD), and had a variety of influences on the research and design of modern cold weapons. The rulers of the Tang Dynasty attached great importance to the improvement of the shooting power of the crossbow, and made several improvements, the crossbow in the Tang Dynasty played an important role in the border defense and city defense, and the actual battle, which is of great significance to the research and shooting of modern cold weapons. Based on this, this paper collects the literature of the Tang Dynasty arrow crossbow, summarizes, and analyzes the content of the literature, and obtains preliminary literature and indicators, which lays the foundation for later analysis. Then, infrared equipment and microscope were used to observe the surface oxide and metal structure of the crossbow to obtain materials and aerodynamic layout. Finally, combined with the research structure of this paper, the influence of Tang Dynasty arrows and crossbows on modern cold weapons is analyzed.

METHODOLOGY

The metal material, external shape, and oxide of the crossbow were observed by a microscope (1080P, electron microscope, Guangdong), and the internal composition of the crossbow was observed by an infrared imager (temperature range 80~120°, Dongguan, Guangdong), and a mechanical measuring instrument (0~500g, pressure film, Guangdong). The quality distribution and other indicators were observed, and the research was carried out in combination with the online literature (www.cnki.con). The observation samples were imitations, the relevant indicators were literature searches, the results were checked with relevant research results, and experts in the field were interviewed.

RESULTS

Materials of the Crossbow

The material and structure of the Tang Dynasty (618-907 AD) crossbow were observed, and the test methods were infrared test and microscopic observation, and the specific results are shown in [Table 1](#).

Table 1. Materials and Structures of Crossbows

Archer Structure	Material	Type	Surface Hardness	Surface Oxides
Arrows	Bronze, tin, lead, iron	Triangular, rhomboid, fusiform	4.32±1.32Hb	Iron oxide, copper oxide
Crossbow	Oak, elm, tung oil, iron nails, cowhide, bone glue	Double S type, S type	1.32±0.32Hb	Tung oil oxides, inorganic salts

From the comparison of the materials of the crossbow in Table 1, it is found that the material of the arrow contains lead, iron, tin, and other substances, which belong to composite metals, and the crossbow body is also made of composite wood, mainly to improve the range and elasticity of the crossbow. In terms of surface hardness, the strength of the arrow is high, and the strength of the crossbow body is low, mainly because the arrow pays attention to lethality, and the crossbow body pays attention to elasticity. Moreover, there is a large amount of oxide on the surface of the crossbow, so it is more resistant to corrosion. The Tang Dynasty arrow crossbow was composed of multiple parts, including the crossbow body, crossbow arm, trigger, arrow crossbow and other structures. The crossbow body is made of high-quality wood, and its tension and elasticity are excellent, and it can withstand relatively high tensions. The crossbow arm is well-made, symmetrical, balanced, and can store enough energy while releasing arrows at high speeds. There was another component of the crossbow during the Tang Dynasty - the trigger. The crossbow body of the Tang Dynasty arch bow is made of high-quality wood, and it is made of sycamore wood with good toughness, which has good elasticity. The reason why the material of the crossbow body is particularly particular is that it will affect the shooting performance and stability of the crossbow. The crossbow body made of high-quality sycamore wood is extremely tough and can withstand the high tension caused by the extremely high tension, thus ensuring the stable discharge of arrows. At the same time, the crossbow should also be elastic enough, which allows it to store the required energy when the string is unwound, and in the process of release, the energy is directly converted into the kinetic energy of the arrow launch. A crossbow with a sufficiently resilient body will allow the arrow to fly faster, while at the same time, increasing its range and power for better precision against enemies. Moreover, the design of the crossbow body of the Tang Dynasty was also very reasonable, not only to have enough pulling force to ensure the stability of shooting, but also to meet the requirements of ease of operation, so that the shooter could better control, to aim accurately and then shoot (Chugunov et al., 2020). In addition, the crossbow body made of high-quality sycamore wood also has good moisture-proof and anti-cracking performance, and can remain stable in different environments. The trigger is delicately designed, flexible and stable, allowing the soldier to precisely control the timing of the arrow's fire by pulling the trigger. The crossbows of the Tang Dynasty were very strong and durable, and they could hold the arrows in place to ensure their flight stability (Fan, 2022). The manufacture of crossbows in the Tang Dynasty is also a part of this article that needs to be analyzed. According to relevant historical records, the production process of crossbows in the Tang Dynasty was relatively complex, and it was very delicate and durable. In the Tang Dynasty, the production process of arrows and crossbows generally had to go through many cumbersome processes, including material selection and cutting, carving, assembly, etc. When making arrows and crossbows, craftsmen must have extremely exquisite carpentry skills, and have a deep understanding and understanding of the manufacturing principles of cold weapons (Gardela & Kajkowski, 2021). It is very important for modern people to continuously improve the combat effectiveness of weapon systems, especially the range and accuracy of weapons, and we need to pay attention to this. In short, the relevant research on crossbows in the Tang Dynasty has an important enlightening effect on the improvement of the manufacturing process and shooting ability of modern cold weapons, and the observation of the surface of the crossbow shows that there are many crystals on its surface, as shown in Figure 1.

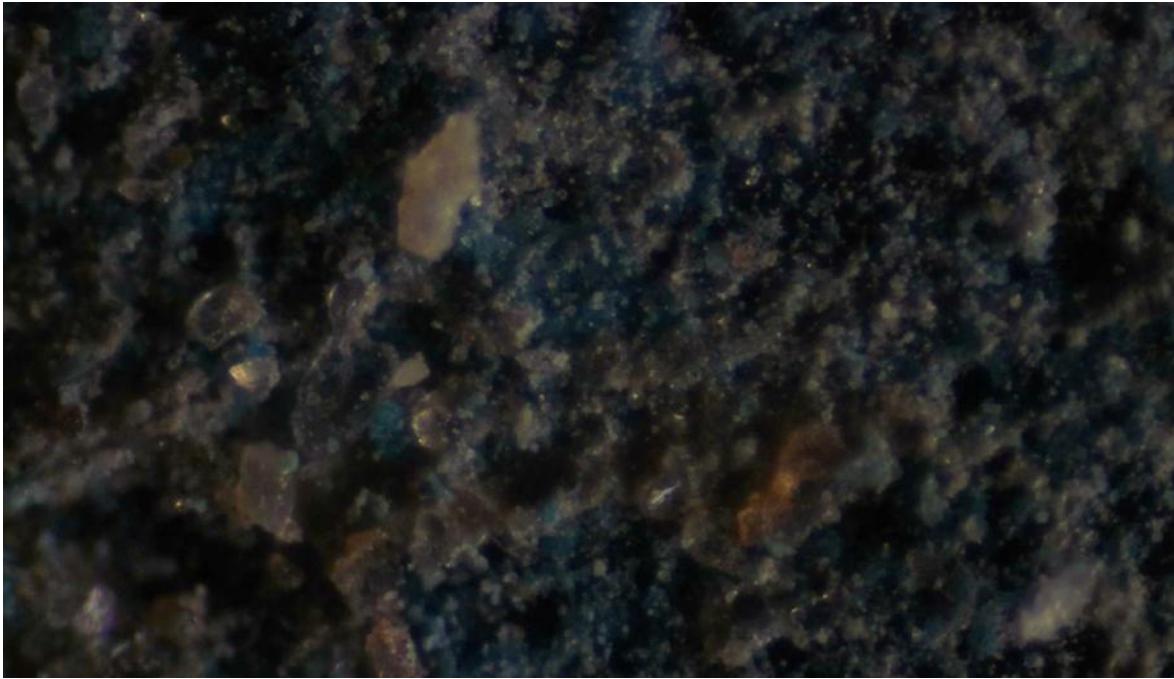


Figure 1. Crystallization on the Surface of the Crossbow

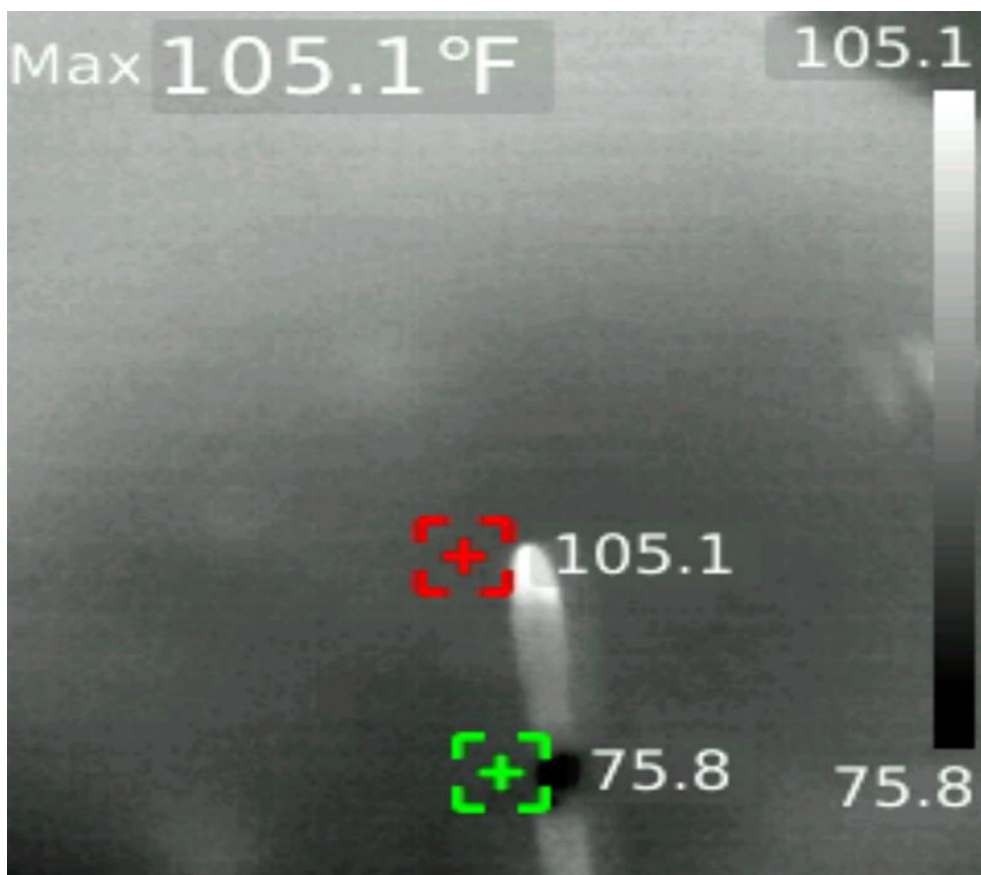
The appearance of crystalline salts on the surface of the crossbow indicates that the surface oxide of the crossbow can be preserved for a longer time. Tang Dynasty arrows and crossbows have a multifaceted value. Early Tang Dynasty (618-807 AD), The crossbow is made of wood as the main material, so it is made through a tedious process, so its structure is relatively simple. In the development process of the Tang Dynasty, the crossbow had a variety of characteristics, such as average range, average power, etc., and did not have a strong advantage on the battlefield. Although the early Tang Dynasty arrows and crossbows did not have a strong range advantage and lethality, they also improved the combat vitality of the Tang Dynasty infantry to a certain extent, and at the same time, they also improved the tactical ability of the infantry in the process of tactical improvement. New materials such as lead and tin were introduced into the Tang Dynasty crossbow for processing and manufacturing, and its stability and durability were improved (Grigoriev, 2021). The range of the Tang Dynasty crossbow has been significantly extended, and its accuracy has been greatly improved. In terms of power, it has also been improved, and in combat use, flexibility and diversity can be improved. In addition, the Tang Dynasty arrow crossbow became one of the main long-range weapons in the Tang Dynasty army, and played a strong role in offensive and defensive battles. It also played a certain role in changing the army's war strategy and city defense layout, which could greatly improve the combat capability of the Tang Dynasty army.

Structure of the Crossbow

Comparing the structure of the crossbow, it is found that there are many shapes of the crossbow, mainly diamond-shaped and triangular, and its structure has the characteristics of reasonable gravity distribution and symmetrical structure, as shown in Figure 2.



Triangle



Oval

Figure 2. The Shape of the Arrow

The infrared test results of the arrows in Figure 2 show that the heat of the arrows is obvious, and the hot spots are focused on the arrows, which are located at 1/3 of the arrows, indicating that the gravity distribution of the arrows is reasonable. In battle, as long as the soldier makes reasonable use of the trigger, he can better

improve the shooting hit rate, and at the same time, achieve the goal of accurately hitting the enemy at the critical moment. The mechanical balance can make the trigger system have the characteristics of stability and flexibility, which can help the operation, reliability, and convenience of the crossbow in the Tang Dynasty to greatly improve, so as to better cope with various complex events on the battlefield (Irannejad, 2020). Overall, the trigger of a crossbow during the Tang Dynasty was an important part of the timing of a soldier's shot. In the Tang Dynasty, the aiming device was extremely important to help the shooter aim accurately, and the mechanical balance of the arrow could improve the accuracy of aiming. Generally speaking, its aiming device includes various components such as front sight and sight, which can provide the shooter with information such as the target direction and target distance, which can allow the shooter to better adjust his shooting angle and strength, and then achieve the purpose of accurate shooting (Kong et al., 2023; Shen et al., 2020). Using the sighting device, the shooter will lock onto the target faster and improve the shooting accuracy. Secondly, on the battlefield, the aiming device of the crossbow can also help the shooter better deal with targets in different conditions and at different distances, and help the shooter deal with various complex situations. The crossbows of the Tang Dynasty had well-designed and efficient aiming devices, which could help the shooters achieve better combat results. The stability and accuracy of the final shot can be determined, so improving the operability of the crossbow trigger will greatly improve the combat usefulness of the crossbow. The center is at 1/3 of the way, which can be in gravitational equilibrium with the arrow feather, and the mechanical balance is shown in Figure 3.

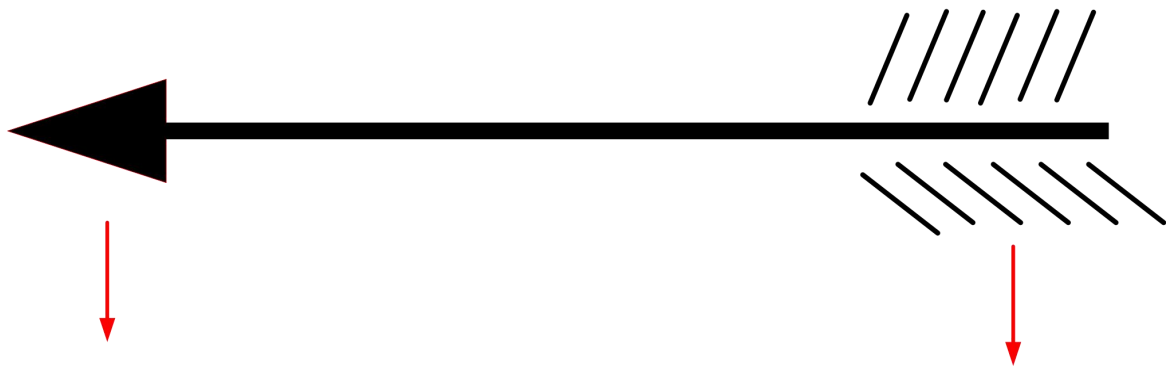
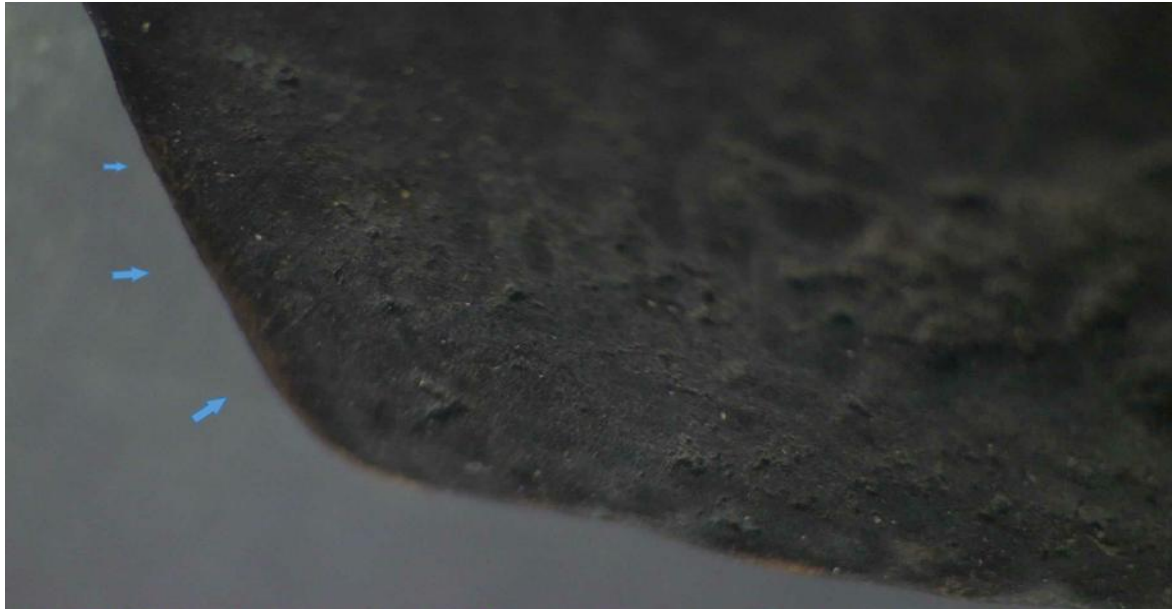


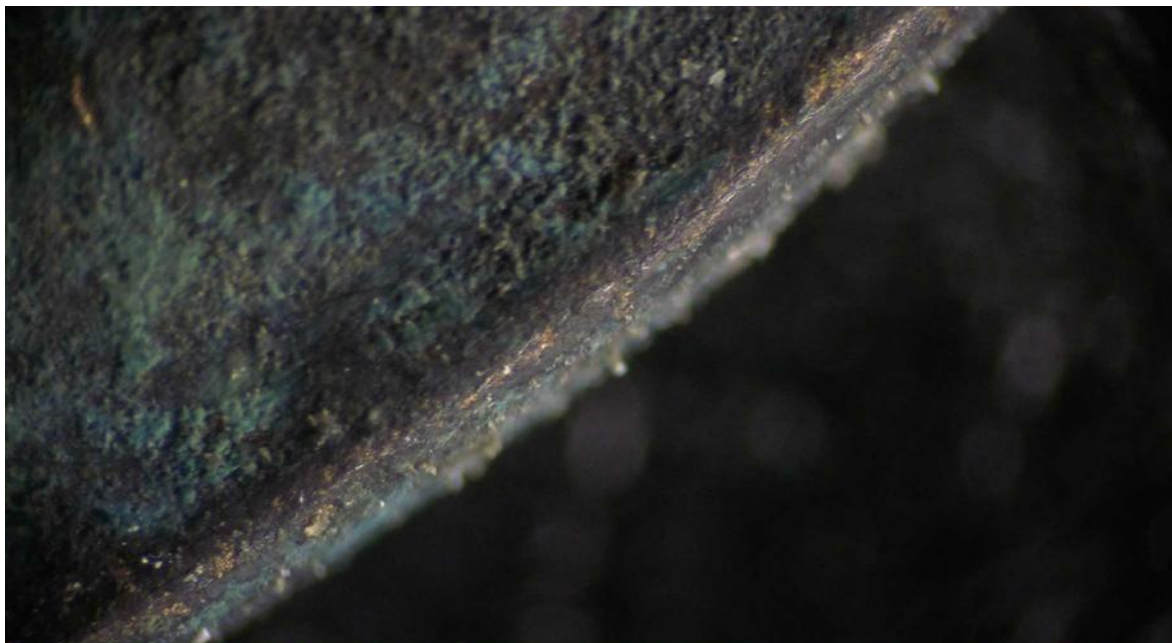
Figure 3. Comparison of the Centre of the Gravity of the Crossbow in Flight

Tang Dynasty (618-907 AD), The structure of the crossbow is more complex and refined, and it is equipped with more advanced sighting devices, optimized triggers, etc. At the same time, it also has a variety of characteristics, such as a very high range, very high accuracy, and can exert strong combat ability and flexibility on the battlefield, showing great power. Moreover, in this period of development, the Tang Dynasty arrows and crossbows also have high military application value, especially becoming one of the main long-range weapons in the Tang Dynasty, and have been applied on a larger scale on the battlefield, with the effect of changing the pattern of war and command strategy. In the process of the development of the arrow crossbow, the initial simple structure, the later structure continued to mature and improve, and the military technology and warfare methods it showed were different (Luo et al., 2020; Park et al., 2023). The Tang Dynasty was a period of military strength in Chinese history, the Tang Dynasty arrow crossbow manufacturing technology level was much higher than the Spring and Autumn Period, the Warring States Period, the Han Dynasty and other dynasties, the Tang Dynasty period of the arrow crossbow has the characteristics of long range and high precision, can effectively combat the arrogance of the enemy army in a long distance. On the battlefield, the soldiers of the Tang Dynasty army generally used heavy arrows and crossbows to suppress the enemy's long-range firepower, which could greatly weaken the morale of the enemy army and reduce the number of enemy troops quickly and accurately (Pollard et al., 2023; Wang et al., 2021). For example, in actual combat, Tang Dynasty soldiers would constantly fire at enemy positions and assembly points from a long distance to create continuous pressure on the enemy, thus forcing enemy soldiers to take deployment adjustment measures and launch defenses. In this way, the morale of the enemy army will be greatly weakened, and the enemy's strength will be reduced quickly, accurately, and ruthlessly, thus creating more favorable conditions for the victory of the Tang army. The crossbow arm is a key component of the overall structure of the crossbow in the Tang Dynasty, and in the overall structure of the crossbow in the Tang Dynasty, the crossbow arm has always assumed the functions of supporting and transmitting power, ensuring balance and stability. Based on this, the symmetrical and balanced design can make the overall mechanism of the crossbow more stable and durable, and is conducive to improving the overall operation efficiency and battlefield performance of the crossbow system. Moreover, on the battlefield, the soldiers of the Tang Dynasty could also

better hit the target through the powerful lethality and shooting accuracy of the heavy arrow crossbow, and then strike the enemy's main generals or key troops to completion, so as to disrupt the enemy's command system and combat plan, thereby turning the tide of the battle at a critical moment and reducing the enemy's follow-up combat ability and effectiveness. It was precisely because of the extensive use of arrows and crossbows by the army during the Tang Dynasty (618-907 AD) that their long-range firepower strike capabilities were greatly improved, and provided certain support for the strengthening of the military strength of the Tang Dynasty army. Moreover, the edge of the crossbow has been quenched, which has high hardness and penetration, as shown in [Figure 4](#) for microscopic observation.



Edge Metal Deposition



The Width of the Surface

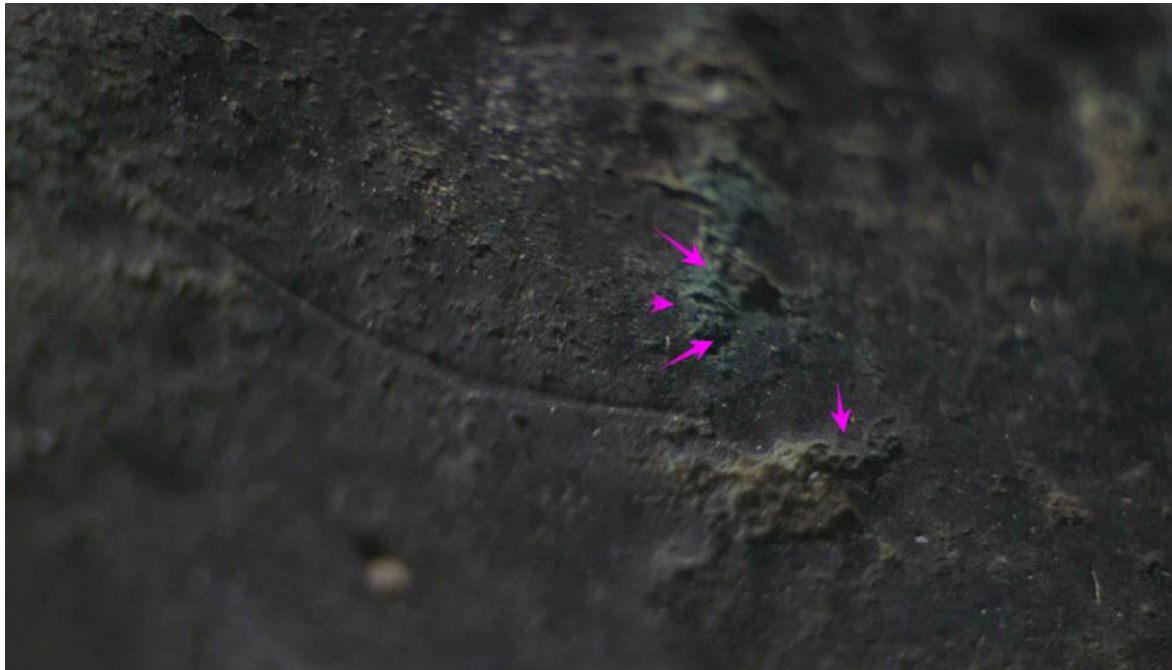
[Figure 4](#). The Edge of the Crossbow

As can be seen from [Figure 4](#), the amount of alloy deposition on the edge of the crossbow increases, but the edge is not sharp, but presents a frustration shape, mainly because the edge of the crossbow is too sharp, which is not conducive to storage, and the damage of the crossbow to the enemy is mainly kinetic energy and potential energy, so the frustration of the edge of the crossbow is conducive to penetrating the armor. During the Tang

Dynasty (618-907 AD), the crossbow could play an important role in the siege and defense of the army. The Tang Dynasty army often used arrows and crossbows to fire at the enemy from the city walls, thus effectively stopping the enemy's siege and improving the army's city defense capabilities. Moreover, in the city defense of the Tang Dynasty army, the long range and high accuracy of the arrow crossbow are great advantages, which can effectively play the defensive ability, thereby improving the morale of the army and maintaining a strong defense mentality, so as to win the battle. For example, in the process of defending the city, the Tang army would use a lot of arrows and crossbows to fire at the enemy continuously. They will increase their firing power by setting up enough firing points and arrow towers on the city walls, so as to suppress the enemy's siege troops, disrupt the enemy's offensive pace, improve the accuracy of shooting at the enemy, and create enough chaos for the enemy, so as to improve the overall defense capability of the city (Qiu et al., 2023; M. Zhang et al., 2021). In the wars of the Tang Dynasty, there were not many cases of the Tang army using arrows and crossbows to achieve effective city defense effects, for example, in the main battle of the Anshi Rebellion, the Tang army used arrows and crossbows to shoot long-range at the attacking siege troops, and by setting up enough arrow towers on the city wall, equipped with a large number of heavy arrows and crossbows and soldier strength, etc., to carry out fierce shooting and fire suppression against the enemy, so as to successfully defend their cities. If the edges are strengthened, the elastic power of the bow will be brought into play. The crossbow arm is symmetrical and balanced, it can store energy and release arrows. The crossbow arm design pays great attention to symmetry and balance, to ensure the stability and balance of the crossbow when the soldier pulls the string. The symmetrical and balanced setting of the crossbow arm will allow the tension caused by the string to be evenly distributed on the overall structure of the crossbow, so as to avoid deformation and damage caused by excessive force on one side. In this way, the archer can control the crossbow more accurately, to shoot better and improve the overall shooting accuracy. In the process of shooting, it plays a key role in storing energy and releasing arrows. When the soldier pulls the string, the crossbow arm stores capacity, and then when released, the energy is directly converted into the kinetic energy of the arrow, allowing the crossbow to fly out. The symmetrical crossbow arm stores and releases energy faster, increasing the speed and range of the arrow, thus increasing the ability to strike enemies (Yang et al., 2023; X. Zhang & D. Zhang, 2023). The Tang Dynasty army used heavy arrows and crossbows to improve its ability to defend cities, which had a good effect and showed strong professionalism and effectiveness. Through reverse observation, it is found that the production of crossbows in the Tang Dynasty was mainly casting, and the edges were quenched at high temperatures, to improve the efficiency of casting arrows, as shown in [Figure 5](#).



Reverse Observation of Quenching



Casting Traces

Figure 5. Casting Observation of the Crossbow

As can be seen from Figure 5, there are large casting marks on the surface of the arrow, and the hardness of the edge is stronger. During the Tang Dynasty (618-907 AD).The Tang Dynasty army could also use the extensive arrangement and large number of crossbows to change the battlefield pattern. For example, on certain battlefields, at certain critical moments, Tang Dynasty soldiers could use heavy arrows and crossbows to fight a wide range of battles and deliver precise strikes against the enemy's main generals, thereby disrupting the opponent's plans and turning the tide of the war. For example, the Tang Dynasty army could use the large number of heavy arrows and crossbows to show their power on the battlefield, and use the range advantage of heavy arrows and crossbows to improve the combat accuracy of soldiers, so as to strike enemy generals or main troops. In this way, it can effectively inflict casualties on the enemy, which in turn weakens the enemy's command and morale, and turns the tide of the battle. In some of the historical battles of the Tang Dynasty, there were many battles in which the Tang Dynasty army used heavy arrows and crossbows to achieve the purpose of changing the pattern of the battlefield. For example, in the 3rd year of Kaiyuan (715 AD), the Tang Dynasty had a war with the Arab Empire, which was also the first of the six wars between the Tang Dynasty and the Arab Empire. In this war, the Tang Dynasty army of more than 10,000 people, traveled to Qiuzi, and went west, chasing the enemy thousands of miles away, and then, using powerful long-range weapons, successfully captured hundreds of cities, which can be described as a long drive. In a certain battle, the Tang Dynasty generals found a small setback of the Arab army, stationed on a certain high ground, commanding the battle, so they ordered the soldiers of their own army to use heavy crossbows to continuously fire accurately at the enemy, so that under several rounds of continuous fire, the opponent was able to be routed and won the victory. Moreover, in some battles of the Anshi Rebellion, the Tang Dynasty army also used heavy arrows and crossbows to carry out concentrated long-range firepower strikes, which greatly affected the morale of the enemy and then changed the pattern of the battlefield. It can be seen that the Tang Dynasty army had a lot of experience in using arrows and crossbows to change the tide of battle. Thirdly, to increase the independent combat capability of infantry units. During the Tang Dynasty (618-907 AD), the crossbow could provide enough combat power for the infantry units, and the infantry units could be independent of the combat capability. If there was no cavalry support, then, in this case, the Tang Dynasty infantry units could use heavy arrows and crossbows to suppress and attack from a distance. Thereby increasing the independent combat capability of infantry units. For example, the manufacturing process and design of the Tang Dynasty arrow crossbow have reached a very high level, at that time, the characteristics of the arrow crossbow is that it can shoot from a long distance and can strike at the enemy with high accuracy, so that the infantry troops can rely on their own strength to achieve fierce attack and fire suppression of the enemy, so as to achieve the purpose of independent combat. Moreover, even in the face of a relatively passive situation, such as being surrounded by enemy troops, then the Tang Dynasty army was able to use well-made heavy arrows and crossbows to achieve a fire response against the enemy, thereby weakening the enemy's offensive. In this way, it is possible to delay as

much time as possible, turn the situation around, and increase the degree of flexibility in the complex battlefield.

DISCUSSION

The Influence of the Study of Arrows and Crossbows on Modern Cold Weapons in the Tang Dynasty

Enhance the Design Concept of Modern Cold Weapons

During the Tang Dynasty (618-907 AD), the various values of arrows and crossbows can become a reference for modern cold weapon research, and have a certain influence on modern cold weapon research. The design concept of the Tang Dynasty arrow crossbow was to combine these design elements (crossbow body, crossbow arm, trigger, aiming device, arrow crossbow) to complete the overall function. There are many details in the design concept, including range, accuracy, stability, shooting power, etc. Inspired by this, the design of modern cold weapons also includes these factors. It can be seen that the design concept is an important aspect of the influence of the crossbow on modern cold weapon research in the Tang Dynasty. First of all, the bow body. During the Tang Dynasty (618-907 AD), the bow body of the archer was made of high-quality wood, which had strong elasticity and tensile force. It has a key impact on the material part of modern cold weapons research. For example, modern cold weapons attach great importance to the stability and elasticity of materials, which is affected by this, so it can be seen that the production of modern cold weapons usually uses alloy materials and composite materials to improve the durability and performance of cold weapons. Secondly, the crossbow arm. During the Tang Dynasty, the crossbow arms of the crossbow were very symmetrical and balanced, and this design could achieve the goal of storing energy and releasing arrows. This has a certain impact on the structural research in modern cold weapon research. For example, the design and structure of modern rifles take into account the principle of balanced distribution of forces, which is similar to the symmetry and balance principle of the crossbow arm in the crossbow in the Tang Dynasty. Then, the trigger. During the Tang Dynasty, the trigger of the crossbow was designed to control the arrow's timing to ensure the shot's accuracy and stability. For modern cold weapons research, this has also brought a significant impact. For example, the shooting system of modern cold weapon research attaches great importance to precise control and convenience of operation, which is influenced by the design of the crossbow trigger in the Tang Dynasty. And then the sighting device. The sighting device of the crossbow during the Tang Dynasty could help the shooter aim at the target and achieve a certain degree of accuracy. This is also an important influence on the research of aiming technology in modern cold weapons. For example, the aiming technology of modern cold weapons is highly developed, and the use of sighting devices such as red dot mirrors is influenced by the design of sighting devices for crossbows in the Tang Dynasty. And finally, the crossbow. During the Tang Dynasty, the crossbow of the arrow could play the role of fixing the arrow while keeping the arrow flying steadily. This has a certain impact on the study of the flight stability of modern cold weapons. For example, the design of some modern cold weapons will use aerodynamic shape design to maintain stable flight. By borrowing from the various parts of the design concept of the crossbow in the Tang Dynasty, modern cold weapon researchers have applied it to their own research and design so as to improve the various key indicators of the modern cold weapon system to adapt to the current complex and changeable battlefield environment.

Strengthen the Matching of Modern Cold Weapon Casting Materials

During the Tang Dynasty (618-907 AD), the crossbow was made of high-quality wood, and its manufacturing process was very exquisite, which greatly influenced the selection of materials and the production process of modern cold weapons research. For example, modern cold weapon research attaches great importance to the selection of materials and the degree of fine fabrication to improve the performance and durability of cold weapons. First of all, during the Tang Dynasty, arrows and crossbows were made of high-quality wood, and the research of modern cold weapons was also affected, and great attention was paid to the selection of materials, for example, modern cold weapons were made of high-strength alloy steel and composite materials. This is influenced by the choice of materials for crossbows during the Tang Dynasty. For example, crossbows in the Tang Dynasty were made of wood because there were specific requirements for the stability and elasticity of the materials. Secondly, the production technology of arrows and crossbows in the Tang Dynasty was exquisite, which also impacted the research of modern cold weapon production technology. For example, modern cold weapon research attaches great importance to the refinement of the production process, which happens to be influenced by the refinement requirements of the crossbow production process in the Tang Dynasty. Based on this, the research of modern cold weapons tends to focus on the research of CNC machining and other technologies so as to ensure the accuracy and stability of modern cold weapons. Finally, the choice of materials and the pursuit of craftsmanship in the manufacture of crossbows during the Tang Dynasty also affected the research on the reliability and

durability of modern cold weapons. For example, modern researchers of cold weapons attach great importance to the choice of materials in producing arrows and crossbows, especially the requirements for high-quality wood and exquisite craftsmanship and the inspiration behind them. For example, the reason why crossbows in the Tang Dynasty needed to be made of high-quality wood and exquisite craftsmanship was to improve the durability and anti-wear ability of weapons, which made modern cold weapon researchers deeply inspired and let them try to continuously improve the durability and anti-wear ability of modern cold weapons in the design and production process, so as to ensure the stability and efficiency of modern cold weapons in long-term use and improve their combat capabilities.

Deepen the Aerodynamic Research of Modern Cold Weapons

During the Tang Dynasty (618-907 AD), the crossbow showed a strong long-range shooting power on the battlefield, which greatly impacted the research of shooting accuracy and range in modern cold weapon research. For example, due to this, modern cold weapon research has strict requirements to improve the design accuracy and range of weapons. First of all, there is an improvement in accuracy. Modern cold weapons are based on the introduction of sighting devices and laser sight technology to improve the shooting accuracy of weapons. In this way, the shooter will aim more accurately at the target while ensuring that the bullet can hit the target—secondly, long-range strike capabilities. Influenced by the design of crossbows in the Tang Dynasty, modern cold weapons attach great importance to improving long-range strike capabilities, so after continuous attempts, modern cold weapons researchers have achieved good results in the two aspects of increasing the range and distance and improving the hit rate. They can achieve the task of striking targets at a long distance. For example, some long-range shooting weapons can accurately hit targets at relatively long distances.

Then, versatility. The crossbow in the Tang Dynasty had many functions, and this versatility brought certain enlightenment to modern cold weapon researchers, so the design of modern cold weapons attached great importance to improving the versatility of weapons to adapt to flexible applications in different combat scenarios. For example, some modern cold weapon systems can switch between modes and ammunition types to suit different combat needs—finally, fire suppression. During the Tang Dynasty (618-907 AD), the crossbow used continuous fire to suppress the enemy's morale and gain battlefield superiority. This kind of tactical thinking has also inspired modern cold weapons researchers. In the study of modern cold weapons, great importance is attached to the study of firepower suppression and long-range strike capabilities to facilitate the development of the battlefield. For example, in the study of modern cold weapons, fire suppression has sufficiently high long-range strike ability, precision strike ability, and diversified firepower, all influenced by the design of arrows and crossbows in the Tang Dynasty.

CONCLUSION

During the Tang Dynasty, the crossbow was a long-range shooting weapon that was widely used in military applications, and it had a long-range solid striking ability and accuracy. Since the time of Li Shimin, Taizong of the Tang Dynasty, the application of arrows and crossbows in the Tang army has gradually been paid attention to and has played an important role in many battles. After continuous improvement, the power of the arrow crossbow also increased, and at the same time, its manufacturing process and technical equipment strength significantly improved. In this paper, the structure and structure of the arrow crossbow are observed by microscope and infrared equipment, and it is found that the manufacturing process is quenching and casting, and the material contains tin, lead, and other materials, and the center is located at $1/3$ of the arrow, which has a high mechanical balance. The surface of the crossbow produces substances such as iron oxide and copper oxide, which are resistant to corrosion. The shape of the arrow crossbow is triangular and diamond-shaped, and the edge is quenched and strengthened, which is not sharp and has high actual combat performance. The advantages of materials and structure give the crossbow a long-range solid strike capability and enable it to continuously suppress the enemy's firepower to strike the enemy accurately. At the same time, the Tang Dynasty arrows and crossbows profoundly impacted the research of modern cold weapons, inspiring modern people to continue improving the range and accuracy of cold weapons and improve the final combat effect. This study has some shortcomings, such as difficulty obtaining samples and a lack of reference data, so we will pay attention to data collection and samples in the future.

REFERENCES

- Anooshahr, A. (2020). The elephant and imperial continuities in North India, 1200–1600CE. *The Indian Economic & Social History Review*, 57(2), 139–169. doi: 10.1177/0019464620912614
- Apendiyev, T., & Satov, E. Z. (2020). Some materials related to the national independence of Kenesary Khan's movement. *Bulletin of the National Academy of Sciences of the Republic of Kazakhstan*, (6), 348-354. Retrieved from <https://journals.nauka-nanrk.kz/bulletin-science/issue/download/47/35#page=353>
- Böhm, M. (2021). Isaac I Komnenos (1007-1060). Army Chief, Rebel, Emperor- In search of his military doctrine? *Vox Patrum*, 77, 81-95.
- Bossler, M. C. (2020). He was not born to Zella! The Hesse-Darmstadt Court Gunsmith Johann Peter Bossler and his Dynasty. *Waffen-Und Kostumkunde*, 62(2), 151-174.
- Candelora, D. (2021). Grisly trophies: Severed hands and the Egyptian military reward system. *Near Eastern Archaeology*, 84(3), 192-199. doi: 10.1086/716230
- Chen, D., Yang, Y., Wang, T., Wang, X., & Luo, W. (2022). Improvement and integration: Scientific analyses of willow-leaf shaped bronze swords excavated from the Shuangyuan Village Cemetery, Chengdu, China. *Heritage Science*, 10(1), 92. doi: 10.1186/s40494-022-00725-2
- Chugunov, K. V., Rawson, J., & Grebnev, Y. A. (2020). Allies and victims: Identifying a steppe component within Shang culture. *Stratum Plus*, (2), 409-438.
- Fan, C. X. (2022). New interpretations of the bronze inscriptions on Shenyin Zhengcheng of the state of Xu. *Linguistic Sciences*, 21(4), 428-442. doi: 10.7509/j.linsci.202110.034692
- Gardęła, L., & Kajkowski, K. (2021). Slavs and snakes: Material markers of elite identity in viking age Poland. *European Journal of Archaeology*, 24(1), 108-130. doi: 10.1017/ea.2020.36
- Grigoriev, S. A. (2021). The problem of south Siberian contacts in the formation of Chinese metallurgy of the bronze age. *Vestnik Tomskogo Gosudarstvennogo Universiteta*, 109-119. doi: 10.17223/15617793/471/13
- Irannejad, A. M. (2020). Kavis in the ancient national Iranian tradition. *Iranica Antiqua*, 55, 241-277. Retrieved from https://www.academia.edu/download/66710892/Irannejad_2020_Kavis_in_the_Ancient_National_Iranian_Tradition.pdf
- Karamursel, C. (2023). Relics of an unwanted past: Slavery, polygamy and the harem at the end of the Ottoman Empire. *Gender & History*. doi: 10.1111/1468-0424.12755
- Kong, D. Y., Kim, J. H., Park, E. Y., Cho, Y. C., & Yang, K. H. (2023). Non-destructive material analysis of whetstones discovered in grain transport ship of the early Joseon period. *Economic and Environmental Geology*, 56(6), 661-674. doi: 10.9719/EEG.2023.56.6.661
- Li, X. (2023). River defense and fleet building: The song navy in the wars against the Jin and Mongol forces. *Journal of Chinese Military History*, 12(1), 24-39. Retrieved from https://brill.com/view/journals/jcmh/12/1/article-p24_3.xml
- Luo, W., Song, G., Hu, Y., & Chen, D. (2020). Tentative determination of a special bronze material by multiple technological test on a Xuan-Liu dagger-axe from the Xujialing Site, the Eastern Zhou period, Henan Province, China. *Journal of Cultural Heritage*, 46, 304-312. doi: 10.1016/j.culher.2020.06.016
- Park, G. Y., Lee, H. B., Oh, Y., Lim, J. A., & Lee, M. W. (2023). Innovativeness in tradition: A study on the physical performance of leather scale armors during the Joseon Dynasty. *Fashion and Textiles*, 10(1), 26. doi: 10.1186/s40691-023-00344-w
- Pollard, A. M., Zhang, Y., & Liu, R. (2023). Bronze alloying recipes at Anyang during the Shang Dynasty. *Archaeological and Anthropological Sciences*, 15(10), 156. doi: 10.1007/s12520-023-01853-x
- Qiu, T., Liu, Z., Li, Y., Yan, X., & Li, Y. (2023). Scientific analysis of bronze objects of the first millennium to the second century BCE excavated from the Jiangkou Site, Pengshan, Sichuan. *Archaeological and Anthropological Sciences*, 15(10), 151. doi: 10.1007/s12520-023-01846-w
- Shen, Y., Su, Q., Jia, T., & Zhou, X. (2020). Characteristics of the site selection and the layout of the Great Wall of the Ming dynasty from a military perspective: Xiaohekou section as an example. *Frontiers of Architectural Research*, 9(3), 541-555. doi: 10.1016/j.foar.2020.02.001
- Wang, X. T., Yang, Y. D., Wang, T. Y., Chen, D. A., Luo, W. G. (2021). Tel:+86 10 15001161179; E-mail:

xiahua@ucas.ac.cn. *Current Analytical Chemistry*, 17(7), 1044-1053.

Yang, D., Wu, X., Liu, R., Wang, Q., Shi, B., Qu, T., ... & Zhang, X. (2023). From diversity to monopoly: Major economic policy change in the Western Han Dynasty revealed by lead isotopic analysis. *Archaeological and Anthropological Sciences*, 15(3), 37. doi: 10.1007/s12520-023-01729-0

Zhang, M., Ge, L., Qiu, T., Gan, Q., Yang, B., & Li, Y. (2021). Forging or casting: New evidence of iron production in the Chengdu Plain in the Han dynasty. *Archaeological and Anthropological Sciences*, 13(7), 111. doi: 10.1007/s12520-021-01349-6

Zhang, X., & Zhang, D. (2023). A study on the aesthetics of calligraphy of bronze inscriptions in the pre-Qin and Jin dynasties. *Herança*, 6(2), 102-116. doi: 10.52152/heranca.v6i2.772