A Comparison of the Metallurgic Industries of the Carthaginian, Seleucid, and Han Dynasty Empires

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Abstract

This paper investigates the geologic and metallurgical landscape of the Carthaginian, Seleucid, and Han dynasty empires and how they benefited these civilizations through industry between the 6th and 1st century BCE. Specifically, this paper compares the unique access, refinement, and impacts of metallurgy of each civilization using the analysis of scientifically rigorous studies and articles. These products include, but are not limited to, coins, weapons, farming equipment, cooking vessels, jewelry, and other commodities. This research also aims to explore the potential impact of these ancient conditions onto the larger political-economic status of the world. All three empires relied on long-distance transport of ores and centralized refining sites. However, the Carthaginian and Han Dynasty empires both achieved heavily centralized control over the production of metal products for wealth and military infrastructure while the Seleucid empire only standardized coin minting and gained related administrative stability and access to inter-regional trade. Such lasting impacts are the preservation of regional trade systems by the Carthaginians and Seleucids and the lasting state relations with industry under the Han Dynasty.

Introduction

Throughout the Iron Age, many civilizations developed powerful political, economic, and social institutions. This sturdy foundation allowed civilizations to form complex systems like imperialism, centralized government, and interconnected trade of regional goods over a long period of time. One of the most important developments from these systems was the field of metallurgy, yet how it developed had vastly differed between regions and empires. Between the 6th and 1st century BCE, North Africa's Carthaginian empire, the Middle East and West Asia's Seleucid empire, and East Asia's Han Dynasty empire each held unique metallurgic traditions and advancements. This variety was partially rooted in the formation of distinct cultures and ways of life due to specific geographies and histories, an analysis largely outside the scope of this research. Instead, this paper compares the Carthaginian, Seleucid, and Han dynasty civilizations from the 6th and 1st century BCE over their access to ores, established metal working systems, level of administrative control, and the industry's benefits for the empires in addition to the industries' impact today.

This paper would be the first to connect the findings of other researchers into an introductory summary of metallurgy of these three specific empires, offering a way for others to contextualize the distinct differences of the metalworking world between the 6th—1st century BCE. However, there exists a variety of research available between these empires and their metal industry. A fair amount of research overviews Carthaginian industry, with articles overviewing the local mining (Delile et al. 9764), industrial bloomery production (Kaufman et al. 33), and the following economic and military expansion (Kaufman 50). Carthage's metallurgy is viewed as a component of the wider and heavily explored Mediterranean economic system, with current discourse surrounding whether Carthage inherited or innovated its metalworking technology. The Seleucid Empire in contrast is vastly under-researched in terms of papers partially because of the current geopolitical instability and how significant larger and longer-lasting empires that came before and after the Seleucids, like the Romans, are to research. The available articles over the empire's metallurgy highlight the foreign ore importation (Finn-Kandel et al. 2), standardized coin minting industry (Ashkenazi et al. 1), and the specific economic advantages of new coinage (Alinezhad 7). Due to limited research, current discussion revolves around whether the Seleucids minting sites' use of lead because of economic planning or necessary debasement due to a loss in territory. However, there exists a dominating number of papers over the Han Dynasty's metallurgy, with notable articles covering ore circulation (Chen et al. 1), distinct ironworking traditions (Li, G. et al. 1), cultural metallurgic resilience (Li, Q. et al. 1), and impacts of state monopolization (Wagner 5). Current debates primarily question how effectively Han China controlled its administrative metal industry and its impacts. Each article includes extensive archaeometric research concluding the unique sourcing, refining, and implementation of metal artifacts for the empires.

Corroborating this data, this paper determined that all three empires developed long distance trade for metal resources and centralized metal production sites; however, they differed heavily in their control over economic administrative systems over metallurgy and the benefits they gained from them.

Methodology

This paper is split between three analytical sections over the Carthaginian, Seleucid, and Han Dynasty empires as follows, and a discussion section to compare the case studies. Each analytical section begins with an introductory summary of the empire's history. Then, it is split into three main areas of focus on the empire's metallurgy industry, with generally one article for each area. The first article primarily provides background on material sources, the second article overviews the state of the empire's iron industry and administrative control, and the third article offers information on the state benefits. The Han Dynasty section provides an additional source to explore the complexity of the empire's metal industry control. This paper defends every conclusion from each area of focus by highlighting the research process for each article. This paper researched each article in the following procedure: investigating the research objective, methodology, and conclusion including the synthesis of the full story between articles. Key elements such as research sites, artifact composition, and historical context from the articles were recorded to help explain the articles along with each research methodology. The discussion section is split into five groups: the first four to compare the conclusions of geologic sourcing, manner of refinement, administrative control, and the state's benefits between empires, and the last section to highlight the lasting impacts of the metal industry for each region, given some empires were conquered. Lastly, this paper would summarize all the findings in the conclusion section and have its references cited in a bibliography.

The articles mention the use of archaeometric technology to determine key information about artifacts. Below is an explanation of each mentioned technology and what they provided the researchers in the articles.

Carbon dating provides an accurate age of organic materials for up to 60,000 years. Every living thing absorbs carbon 14, a radioactive isotope that decays into other elements at a consistent rate but ceases to upon death. Scientists could determine the date of an organism's death by counting the remaining number of carbon-14 atoms with accelerator mass spectrometry and calculating the years spent decaying (Koppes and Lerner). By carbon dating the surrounding organic artifacts, archaeologists can infer the date of non-organic artifacts like metal for historical interpretation.

Lead Isotope Analysis (LIA) is a minimally destructive procedure to determine the chemical origin of lead metals in an artifact. Lead has four stable isotopes with different rates of decay. Because all lead isotopes aren't significantly impacted by natural or chemical processes from the environment after formation, every isotope ratio is retained as a unique permanent signature that can be used to trace an artifact's material origin. For LIA, the lead must be isolated and purified from possible contaminants before being ionized for analysis. Through a multi-collector inductively coupled plasma mass spectrometer that separates ionized beams of isotopes by weight via magnetic field, highly precise information about the isotope ratios of the artifact can be determined (Wozniak). Through LIA, archaeologists can determine the geologic origin of the lead in an artifact to understand the circulation of resources across a region.

Energy-Dispersive X-ray Spectroscopy (EDS or EDX), when combined with a Scanning Electron Microscope (SEM), acts as a mode of non-destructive chemical analysis by quickly identifying information about the chemical composition of a sample of any material type. A small part of a sample is placed into a machine where the EDS fires an electron beam that knocks an electron from an atom's shell. This leaves a charged vacancy that attracts an electron from an outer, higher-energy shell and the movement from high to low energy shells releases energy in the form of an x-ray. The X-ray is unique to element and transition, allowing software to interpret the information after it's collected by a silicon drift detector. The SEM uses backscattered electrons like light waves to reflect off atoms to produce images highlighting differences in atomic number and topographic information about the sample. The chemical compositions of artifacts analyzed can be compared to other artifacts by archaeologists to learn about materials present, sourcing, and refining processes (Nanakoudis). Knowing the chemical composition and topographic structure of artifacts is crucial in determining the metallurgic materials, origins, and processing style of the artifact.

X-Ray Fluorescence (XRF) is a non-destructive procedure that also provides the elemental composition of a sample. The process fires a high-energy x-ray from a controlled tube through the sample. Once hit, an electron from a low orbital in an atom of the sample is dislodged and a separate electron from a higher orbital fills the vacancy. The electron's movement from high-energy to low-energy orbitals releases a fluorescence x-ray for detection and analysis. The energy and intensity of the fluorescence x-ray identify the type of element and its concentration respectively (Thermofisher Scientific). Detailing the chemical composition of artifacts is crucial in determining the metallurgic materials, origins, and processing style of the artifact.

Microwave Plasma Atomic Emission Spectrometry (MP-AES) uses a microwave field that transforms nitrogen gas into a plasma that atomizes a liquid sample of the artifact. The valence electrons move up and down energy levels, emitting characteristic photons that are detected by a high-resolution spectrometer (Geisenblosen et al.). Similarly, this technique provides researchers an opportunity to determine the materials, origins, and processing style of the artifact.

Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-MS) uses a high temperature argon plasma that has a high energy to atomize a liquid sample to near completion that emits characteristic protons for an optical spectrometer to detect. It can analyze nearly every element due to the high energy available to atomize them (Di Fusco et al.). This technique provides a more expensive but in-depth analysis of material composition than MP-AES.

Inductively Coupled Plasma Mass Spectrometry (ICP-AES) uses the same high temperature argon plasma to rip electrons from the liquid sample to create a positively charged ion stream. The ions are focused into a beam so a mass analyzer (commonly a quadruple) can filter out ions for a specific mass to charge ratio for a detector. It can provide absolute elemental concentrations, and the abundance of isotopes present in the artifact (Zlateva et al.). This technique provides researchers with a more complete set of data to determine the materials, origins, and processing style of the artifact.

Section 1: The Carthaginian Empire

Carthage was founded in 814 BC as a Phonecian colony in the north coast of Africa (modern day Tunisia) to deliver resources as tribute to Tyre which itself sent tributes to several Mesopotamian empires for protection. But by 200 BCE, Carthage had transformed into a powerful economic empire in the Mediterranean. Through several research and interpretation projects, this dramatic rise in prominence was discovered to partially derive from the city's metallurgic industry and trade. Carthage must have had sourced metals to fuel the trade, so research delved into uncovering their mines.

According to an international multidisciplinary research team of geoarchaeologists in their article *Economic Resilience of Carthage during Punic Wars* (Delile et al.), Carthage had a large and local mining industry. The research team produced 810 meter long-sediment cores from harbor basins by the ancient Phoenician city of Utica. Using radiocarbon dating, the team created an age to depth model that correlated layers of each core to the chronologic progression of geologic activity of 37 dates. For only one core, the team used LIAs to chemically separate natural lead densities and Carthage-era (340–96 BCE) lead pollution (Delile et al. 9765–9766). Comparing the distinct 206Pb/204Pb lead isotope ratio of the pollution along with leachate-residue composition to lead from Tunisian mines, the team successfully isolated the origin of the ores. Specifically, they found Carthage derived its lead from the local mines Djebba and Kebbouch in northern Tunisia from 340–95 BCE (Delile et al. 9767). The team contextualizes Carthage's mining with the onset of economic crises like the Greek-Phonecian war (580–265 BCE) and the Punic wars (264–146 BCE) as the metal was used as a key export. In addition, the evidence of only lead mining points towards Carthage's limited accessibility of other ores and a dependence on importing them (Delile et al. 9768–9769).

The magnitude of Carthage's iron industry was highlighted by another international multidisciplinary research team in their article *Ferrous Metallurgy from the Bir Massouda Metallurgical Precinct at Phoenician and Punic Carthage and the Beginning of the North African Iron Age* (Kaufman et al.). The team analyzed a total of 17 samples of slag, tubers, and alloys near a furnace found at the Bir Massouda Site located in the urban center of the city of Carthage. Based on nearby previously dated architectural and artifact remains; the team ranged the dating of the samples between 650–200 BCE. Using XRF, SEM-EDs, and Microscopy (using a microscope), the team recorded the exact elemental compositions of each artifact along with detailed images of the samples (Kaufman et al. 40–41). They then determined three distinct types of ferrous slag distinguished by either a microstructure of a secondary wüstite in a glassy matrix, a microstructure of spinels of primary wüstite in a glassy matrix with some iron silicate, or primary and secondary wüstite in fayalite and glassy matrix. Each type of slag corresponded to a specific step in ironmaking and implied the site all smelted, refined, and smithed iron. But due to the lack of iron ore and no concrete evidence of local iron mining, the team concluded that Bir Massouda metallurgy primarily practiced iron smithing and bloomery of final products using imported and sometimes impure iron blooms (Kaufman et al. 42–45). By observing the wider metal-working site layout of specialized furnaces, hearths, and large quantities of waste products, uncommon for a household workshop, the team also concluded that Carthage had a centralized large-scale ironworking industry in Bir Massouda. Such conditions were determined to focus on producing a surplus, with the likely purpose of trading for profit (Kaufman et al. 46).

Carthage's great industry of smithing metal products provided it a great opportunity for economic power.

In the dissertation *Empire Without a Voice: Phoenician Iron Metallurgy and Imperial Strategy at Carthage* by Brett Kaufman, the economic power from metallurgy was cited as a larger driver in Carthage's evolution from a small colony to an imperial superpower. The dissertation sourced and analyzed multiple earlier research papers and classical sources detailing key sites of Carthage's metallurgy and Carthage's political shifts. Carthage had acted as a Mediterranean trade-port colony for the Tyrinian empire, shipping the empire's metals from other colonies like Sicily and the Iberian Peninsula from its strategic position (Kaufman 16). From its founding in 814 BCE to the late 500s BCE, Carthage's advances in its metal industry also developed its economy when trading with other colonies and empires. After the crisis of the 6th Century BCE and the weakening of Tyre, Carthage assumed independence and began recovering old Tyrian colonies as an empire using their powerful military (Kaufman 30). Carthage's metallurgical advancement provided it with both the advanced weaponry for warfare and the economic advantage to hire mercenary armies, the most primary and prevalent form of military at the time (Kaufman 37–38). Instead of complete dominance, Carthage provided both independence and fortifications for its new allies for trade. Carthage continued to invest in military advancement with metallurgy to defend its wealth and economic power. By the 2nd Century, Carthage had become a powerful "mercantile coercive empire" (Kaufman 51), using its vast colonial holdings to continue strengthening its metallurgic industry and dominate the Mediterranean.

Carthage began as a port colony city in an advantageous trading location, but the region only enabled local lead mining, requiring ore importation from controlled colonies after the city's independence. The empire had developed large-scale centralized iron bloomery worksites for military technologic advancement and iron product exportation in the Mediterranean, bolstering Carthaginian riches and maritime trade.

Section 2: The Seleucid Empire

The Seleucid empire was founded in 312 BCE by Seleucius I out of the fallen Alexander the Great's empire and stretched from Anatolia to the borders of India during its peak. Due to its size, it was a multi-ethnic empire with multiple regional economic traditions including the prevalence of a bartering system in the eastern regions. Shortly after, the empire enjoyed considerable economic and political power over large parts of the Eastern Mediterranean and Western Asia simply due to its strategic positioning in between the Taurus Mountains and Hellespont before falling to the Romans in 64 BCE. Part of this soon collapse was the accumulating losses of territory from local and foreign conflict. Regardless, the Seleucid's sudden and limited power may derive from the empire's institutionalization of standard coin minting that supported its strong military and interregional trade.

To sustain the coin minting industry, the Seleucid empire imported metal resources from a variety of regions. As outlined by the article *Aegean-Anatolian metals in the Hellenistic Southern Levant: new insights from the copper-alloy assemblage of Khirbet el-'Eika* (Finn-Kandel et al.), an Israeli multidisciplinary archaeological research team determined the regional sources of the empire's metal supply. The researchers found 27 copper-based artifacts (jewelry, weapons, coins, etc.) from the settlement Khirbet el-'Eika in the Southern Levant which was under Seleucid control before its abandonment in 144–143 BCE (Finn-Kandel et al. 1–2). Metal powder from the artifacts was drilled out and analyzed under MP-AES to determine the chemical composition of each artifact. Using the chemical composition, the artifacts were split between 5 distinct groups of copper: unalloyed copper, high tin bronze, leaded tin bronze, high lead copper, and gunmetal (Finn-Kandel et al. 3–4). Using LIAS to find the distinct and traceable lead ratios of ten artifacts from only the high tin bronze and leaded tin-bronze groups, the researchers certified that the compositional ores may derive from a mixture from a geographically young copper source, a geographically young lead source, and a geographically old copper source. While the researchers couldn't link either of the copper sources to a specific origin, they could trace the lead source. Seven of these artifacts with a material composition consistent with the young lead source were determined to have been potentially procured from the Tethyan Eurasian metallurgic belt including the Chalkidiki and Thasos mines in the Aegean-Anatolian Province (Finn-Kandel et al. 11). A consistency in the element patterns throughout all artifacts hint at repeated procurement from a consistent source. In the context of Seleucid rule over the territory during the late Hellenistic period and the ensuing requirements for a shift from silver coins to standard bronze coins, this repeated sourcing from the nearby Aegean-Anatolian regions is historically supported. Through the Seleucid empire's access to specific Aegean-Anatolian metal imports, it held a consistent source of metal for its metallurgic industries (Finn-Kandel et al. 16). Additionally, this system is evidence of Seleucid trade with the Mediterranean as a source for other resources.

The Seleucid's industry that heavily required constant metal was coin minting. The extent of the Seleucid minting industry was analyzed by researchers from the German-Israeli Tell Iẓṭabba Excavation project and discussed in the article *Archaeometallurgical Characterization of Seleucid Leaded Bronze Coins: Towards an Understanding of Flans Standardization* (Ashkenazi et al.). The researchers analyzed 22 coins originating from Antioch, Nya-Scythopolis, and Ake-Ptolemais mints using XRF, SEM-EDS, ICP-MS, and LIAs. The coins dated from 150–120 BCE and were found in the Seleucid Nysa-Scythopolis settlement in Tell I Iẓṭabba that lasted under Antiochus IV before being destroyed from 160–107 BCE

(Ashkenazi et al. 1). In addition, the researchers divided the coins into 5 distinct groups based on minting site, reigning king, and date of issue (Ashkenazi et al. 5). The researchers determined the general steps of the minting process were casting the flans (blanks) via mold, heating the flans for preparation, and stamping motifs through observing cut marks from the mold and microstructure traits like globular lead inclusions from chemical analysis that proved flan heating (Ashkenazi et al. 3). Through analyzing the chemical heterogeneous regions of tin and lead in each of the coins, the researchers determined if differences in the chemical content were sourced from age or different smithing techniques. But despite how the coins dated from different mints and rulers, the alloy's copper, tin, and lead composition held a general similarity with variability (Ashkenazi et al. 29). The researchers determined that such consistency was intentional as lead and copper were readily available in the region but tin, a crucial alloying component, was rare in the Middle East and was imported. They concluded that the coin smithing techniques had a degree of standardization throughout the empire, possibly indicating a shared or similar source of materials (Ashkenazi et al. 26). Regardless, the standardized coinage provided a stabilizing economic unity across the wide empire.

This utility was outlined in the article *Coins and the Economic System of the Seleucids* (Alienzhad) which determined the extent of the Seleucid empire's dependence on coinage for their economy by analyzing classical sources, inscriptions, and burial hoards. The article highlights that the Seleucids instituted the Attic trimetallic system (gold, silver, bronze coins) throughout the empire, although some eastern regions still used traditional commodity-based economies (Alienzhad 8). This empire-wide coinage system ensured taxation revenue would be fair and convenient to collect from subjects, especially useful due to the diversity of economic traditions among regions. Crucially, currency enabled consistent payments for state and mercenary militaries, public works, and administrative expenditures, ensuring stability for state expansion, defense, growth, and governance. In addition, neighboring states also used the Attic system so the Seleucids could have both a strong local and inter-empire economy (Alienzhad 9). Through the economic homogeny the metals coins provided, the empire achieved economic power through convenience to trade with nearby regions and gained socio/political power through the funding of militaries, infrastructure, and government.

Inheriting a large multi-ethnic empire that lacked a traditional unified monetary system, the Seleucids struggled with economic and political instability. The empire relied on foreign importation of ores to feed its standardized coin minting industrial sites due to limited ore accessibility. Regardless, the spread of the specific Attic trimetallic coinage system made taxation and funding vastly more efficient for the government and improved regional Middle Eastern and West Asian trade with nearby kingdoms using the same coin system.

Section 3: The Han Dynasty Empire

After the Warring States Period (471–225 BCE) and the short-lived Qin dynasty (221–206 BCE), the Han dynasty established economic and political unity across the once fractured and rivaling regions. Through the Han dynasty's widespread centralization of metal resources and facilitation of inter-regional trade, they were able to achieve staggering economic and political power over the region.

The article *The lead ores circulation in Central China during the early Western Han Dynasty: A case study with bronze vessels from the Gejiagou site* (Chen et al.) detailed a team of Chinese archaeologists' research on the lead ore circulation during the early Western Han period using bronze artifacts found from burial sites in Geijagou village in Nanyang. The site was chosen since the metropolis and region have a highly developed and prosperous metal industry. It was also located in the regional junction during the unification of Warring States Period bronze smelting traditions under the Han dynasty (Chen et al. 1–2). Using SEM-EDS and LIA, 14 bronze artifacts dating from 100 BCE were observed to have significantly varied lead isotope ratios in comparison to the concentrated ratios during the early Warring States Period as found from previous research projects (Zhang and Chen) (Chen et al. 5–7). The researchers determined that all samples may have more than one lead source, but most used ores locally by Nanyang and two used ores from the belt of southern Qinling Mountains (Chen et al. 8). With the context of Nanyang's central location and metallurgic advancement, the researchers suggest the Han Dynasty supported intertrade growth and economic development by circulating lead from as far as southern China for Nanyang's industry (9–10).

In addition to circulating metal resources, the article *Scientific Analysis of Han Dynasty Iron Artifacts Excavated from the Luojiaba Site in Southwest China* (Li, G. et al.) overviews a separate team of Chinese archaeologists' research into the Han Dynasty's support of a multi-tradition metallurgy system. The researchers analyzed 17 iron artifacts of utensils, tools, weapons, etc. dating around 100 BCE from cemeteries at the Luojiaba site using metallographic analysis and SEM-EDS that detailed the unique microstructure and composition of the artifacts (Li, G. et al. 1–2). The analysis divided the artifacts between cast-iron and wrought iron or steel based on distinct traits like the observation of a ledeburite matrix or a ferrite matrix respectively Additional chemical analysis suggests most artifacts derived from a non-centralized production and supply system. The different types of produced iron correlate to the distinct and regional metal refining styles of bloomery iron and 'CHAO'-fining steel contextualized in the isolating Warring States Period (Li, G. et al. 5–6). However, the presence of differently produced iron products in the same site supports the existence of an intraregional exchange of metallurgic tradition and metal resources in the Han Dynasty (Li, G. et al. 11).

The extent of the Han's metallurgic reach is complicated by a Chinese archaeology team's research on the changing dependence on non-local metal resources in the article *Exogenous metal dependence in the upper Yangtze: archaeometallurgical analysis of bronzes in the Ba area from the Eastern Zhou to the Han periods (771 BCE–220 CE)* (Li, Q. et al.). The researchers contextualized the asymmetrical resource imbalance between the Chu and Ba regional provinces and cultures for monopolizing region-exclusive copper and spices respectively. As such, diplomacy to gain and monopolize resources drove violent conflict during the Warring States Period until the Qin unification and Han centralization (Li, Q. et al. 1–2). The researchers analyzed 13 bronze artifacts including cooking pots and weapons from cemeteries in the Ba site, Wanzhou village in Chongqing using ICP-AES, SEM-EDS, and LIA to distinguish chemical composition, metallographic microstructures, and sourcing between the artifacts (Li, Q. et al. 3–4). Local Ba artifacts were made with an exclusive leaded tin bronze composition and a solid microstructure matrix from casting while imported Chu goods were made with recrystallized alpha grains and thinned walls from forging (Li, Q. et al.6). The consistent overlap of

Hunan ore composition in both products demonstrates the Han monopolization and facilitated distribution of metal throughout the regions. Although the present Ba and Chu styled artifacts were both made from Chu copper, high quality and desirable Chu products were still imported and culturally significant Ba bronze artifacts were still locally produced. The researchers hypothesize that because of the cultural significance the locally produced bronze vessels provided the Ba, preservation of the technique is reflective of the preservation of their ethnic identity (Li, Q. et al. 10). The researchers conclude that despite Han centralization of local resources and support of interregional trade and technique, local metallurgic traditions continue to persist (Li, Q. et al. 12).

However, the greatest impact of the centralized metallurgy industry was detailed in *The State & the Iron Industry in Han China* by Donald B. Wagner which discussed the complex advancement of iron metallurgy in China from 800 BCE–1279 CE. Focusing on the time frame researched by this paper, the book analyzed the growing industrial scale of metallurgy through the Warring States Period and the Han Dynasty. Initially during the Warring States Period, Qin dynasty, and early Han dynasty, several individual state governments administered the iron production which provided freedom for industrialists to amass great fortunes (Wagner 3–4). In 117 BCE, however, Emperor Wu-di enacted interventionist economic policies including a state monopolization of the iron industry (Wagner 5–6). Nationalizing large scale blast furnaces, consolidating mining rights, and controlling distribution, the government outcompeted local smiths. Through the administration of "Iron Offices" over ironworks, the industrialized production of 'CHAO'-fining steel grew extensively (Wagner 90). Wagner estimated they produced at least 5,000 metric tons of iron per year (Wagner 73). The Han dynasty was able to mass-produce advanced iron weapons and armory to achieve great military might, to spread iron farming tools like plowshares to drastically boost food production, and to consolidate the emperor's power away from local merchants (Wagner 11–13).

Historically divided over access to ores, distinct metallurgy traditions emerged in regions coinciding with the warring states period. When the Han Dynasty inherited the newly unified empire, they heavily assisted in distribution of metal resources and techniques across the region, although some cultures retained their traditional styles. The Han Dynasty's control evolved to complete administrative monopolization of the ironworking industry, providing mass production of advanced military and farming equipment for the empire and providing great revenue for the government.

Section 4: Discussion

The Carthaginian, Seleucid and Han Dynasty empires relied on some form of long-distance trade and transport of metal resources[1]. Carthage had access to a limited range of ores on the North African coast. Although it could exploit lead mines, it likely needed to import most of the copper and iron necessary for metallurgy. After the crisis of the 6th century and Carthage's ensuing replacement of Tyre as the Mediterranean superpower, it used its maritime military to create new colonies in Sicily, Sardinia, and the Iberian Peninsula. With these distant colonies, Carthage could trade in a constant supply of metal resources to fuel its metallurgy industry. The Seleucid empire had primary access to lead and copper

[1] For citations regarding these conclusions, please see the results section which discusses the individual case studies and their sources in detail.

mines in the middle east and western Asia. However, it is necessary to import tin to achieve the necessary elemental composition for products. Additionally benefiting from supplemental lead importation, the Seleucids established maritime trade in the Mediterranean to gain access to ores from the Aegean-Anatolian Province and fuel its metal working industry. Although the Han Dynasty had access to an abundant supply and variety of ores within its borders, these ores were unequally distributed between provinces. Copper ores were almost entirely exclusive to the Chu region and lead was primarily obtained from the Nanyang province and the belt of southern Qinling Mountains. To ensure distribution of metal resources needed for each region to produce their cultural metal goods and consolidation of resources in heavily industrialized metalworking regions, the Han Dynasty established long distance trade throughout the empire. All three empires required the long-distance trade and transportation of ores to fuel their metallurgy industries.

Furthermore, all three empires institute centralized metalworking sites. Carthage centralized the metallurgic industry at sites like Bir Massuoda through large-scale industrious workshops. Primarily smithing and refining imported iron blooms, Carthage was able to produce a surplus of completed iron products like weapons and vessels for heavy military and trade use. The Seleucid government had a strong coin minting industry as they established minting sites throughout the empire. Over several emperors, these coins followed a standardized process of production and material composition, strictly following the Attic trimetallic system prevalent in the middle east so the empire could economically dominate their region by trading with neighbors using the same coinage system. The Han Dynasty instituted a powerful metalworking industry. Through the new economic policies, the Han government-controlled iron mining rights, administered ore distribution, and monopolized the iron industry with large-scale ironworks. This ensured an incredibly efficient mass production of advanced military equipment and daily goods. The standardization and centralization of metallurgy sites were upheld by all three empires.

However; the empires differed in their level of administrative control. Carthage dominated iron production within the city and exportation through the centralization of production, but they were reliant on trading with mostly independent colonies to import metal resources. Regardless, Carthage acted as a powerful importer and distributor of resources and products respectively to assist in its metal industry. The Seleucids had very little control over the metal industry. They controlled minting with standard requirements of production like what ores to include, but as seen through analysis of the coins, they suffered from variability in chemical composition. In addition, they had no centralizing role in the rest of the industry, ensuring the production of metal goods to be completely controlled by independent subjects. The Han state had dominated the iron industry. Under the interventionist economic policies of Emperor Wu-di, the Han government monopolized the industry through the establishment of administrative offices over each step of production. This process took power and wealth away from private industrialists and gained wealth solely for the government. Although local smiths still produced culturally significant metal vessels and equipment, they still completely relied on the Han's distribution of the necessary metals and were outcompeted economically. Carthage controlled the means of production and distribution but not sourcing, while the Seleucids only controlled minting standardization, and the Han Dynasty controlled every step of the metalworking process.

In addition, the empires differed in these specific benefits they gained from metallurgic advancement. Through Carthage's centralized metallurgy industry, they produced surpluses of metal products and advanced military equipment. Using their metal surpluses, they dominated the iron trade within the Mediterranean and using their advanced military, they took control over more colonies and protected their trade. Such dominance rewarded the empire with great economic and political power. In contrast, the Seleucids only had an advanced metallurgic industry for coin minting which assisted the young empire with diverse economic traditions. Following the regionally popular Attic trimetallic system, the empire was able to partially establish an economic standard among its subjects and free trade with neighboring empires using the same system. The standardized and convenient coinage crucially enabled convenient taxation to regularly fund state militaries, mercenary militaries, public works, and administration. Similar to Carthage, the Han Dynasty had highly advanced iron and steel production along with a plethora of traditional and regional iron smithing techniques. The Han Dynasty's large-scale ironworks used massive blast furnaces that ensured dramatic efficiency in metal good production that provided their military with a technological advantage for conquering and protection while also ensuring the Han government to eliminate local competition and solely profit. The Carthaginians held a strong position in Mediterranean trade, while the Seleucids only gained economic and state order, and the Han Dynasty bolstered their economic and military dominance over their empire.

Shortly after Carthage and the Seleucid's economic prosperity from trade, they were both conquered following long wars against the Roman Empire. As such, the extent of their metallurgic legacy was the continuation of the flow of commerce in the Mediterranean and middle east respectively under the control of Rome. The Han Dynasty, however, established a lasting tradition of heavy governmental intervention in the economy through controlling resource distribution and industry as seen during the Ming ban on foreign trade, the Great Leap Forward, and the interventionist policies of today.

Conclusion

This paper sought to determine the similarities and differences of the geologic access, metallurgic refinement, and state benefits between the Carthaginian, Seleucid, and Han Dynasty empires from 6th–1st century BCE. Non-immediate access to crucial ores was not a restriction for any of the empires as they were all able to establish long-distance trade to obtain resources. In addition, all three empires established standardized metal working industries. However, the level of administrative control from the industry did differ substantially. Carthage centralized only iron production, mainly assisting Mediterranean importation and exportation of metal ores and goods with its army. The Seleucids only centralized the coin minting industry and standardized part of the empire to use it, however the empire's short lifespan potentially impacted this. The Han Dynasty established complete administrative control over the mining, distribution, and production of metal goods. Another significant difference between the empires were the benefits they gained from the metallurgy industry. Carthage had centralized workshops for iron surpluses over Mediterranean trade, and the Han Dynasty had complete control over the distribution of resources, providing both governments the opportunity to expand their wealth and military infrastructure. The Seleucid's coinage industry only granted it great wealth from trading with neighboring kingdoms and stability through partial economic homogeneity, stable taxation, and governmental funding, but nothing else of the economic and political level of the other empires. Carthage and the Seleucid's main metallurgic legacy were their continuation of trade in their commerce-prone regions while the Han Dynasty established a lasting tradition of heavy economic planning and control by the government. In the future, this research could look further into the specific techniques and chemical composition of metal equipment to explore the small and innate advantages and disadvantages of a civilization using them. The research could additionally extend to observe the possible impacts metallurgy had on the foundation and collapse of each empire.

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