

WESTERN ANATOLIAN METALWORK AND
(THE SELF-IMAGE) OF METALWORKERS IN
THE LATER 1ST MILLENNIUM BC – A
HISTORICAL-ARCHAEOMETRICAL APPROACH

A Master's Thesis

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The Graduate School of Economics and Social Sciences of
İhsan Doğramacı Bilkent University

by

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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Archaeology.

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ABSTRACT

WESTERN ANATOLIAN METALWORK AND (THE SELF-IMAGE) OF METALWORKERS IN THE LATER 1ST MILLENNIUM BC - A HISTORICAL- ARCHAEOMETRICAL APPROACH

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June 2023

This thesis displays the level of metalworking technologies utilized by ancient smiths in western Anatolia during the 1st millennium BC. Metalwork in western Anatolia during the 1st millennium BC is an unexplored field of study. Due to certain historical biases and the relatively new emergence of the archaeometrical techniques, there stands a gap between the history of Late Bronze Age and Hellenistic-Roman metalwork in western Anatolia. In contrast to the previous assumption that most of the metallurgical procedures arrived in Ancient Greece through Cyprus and the Levant, the archaeological evidence from western

Anatolia demonstrates that those techniques were already present in the Aegean. Several ancient sites with both Bronze Age and Iron Age layers in western Anatolia, including Gordion, Klazomenai and Sardeis, offer a rich source of material for establishing links between metalworking techniques between the two periods due to the uninterrupted connection their materials present. By exploring the folk tales from Lydia, Mysia, and Phrygia, regions often associated with the origins of certain metalworking technologies and even elements, this thesis aims to uncover the inhabitants' perception of mineralogy. Consequently, the traces of the deliberations of western Anatolian philosophers and mythology are visible in Ancient Greek scientific legacy as seen through Aristoteles. This research highlights the significant influence of western Anatolian metalwork on the scientific legacy of Ancient Greece, both in theory and practice. Additionally, it suggests that western Anatolian metalworkers possessed a theoretical understanding of their work, potentially portraying themselves as keepers of knowledge through their craft.

Keywords: Archaeometry, metalwork, western Anatolia, 1st millennium BC, mythology

ÖZET

M.Ö. İLK BİNYILIN SONLARINDA BATI ANADOLU'DA METAL İŞÇİLİĞİ (VE METAL İŞÇİLERİNİN ÖZ İMGESİ): TARİHSEL VE ARKEOMETRİK BİR YAKLAŞIM

Kayaalp, Aziz Cem

Yüksek Lisans, Arkeoloji Bölümü

Tez Danışmanı: Doç. Dr. Thomas Zimmermann

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Bu tez, M.Ö. 1. binyılda Batı Anadolu'daki antik metal işçileri tarafından kullanılan metal işleme teknolojilerinin seviyesini göstermektedir. M.Ö. 1. binyılda Batı Anadolu'da metal işçiliği yeterince araştırılmamış bir çalışma alanıdır. Belli tarihsel önyargılar ve arkeometrik tekniklerin nispeten yeni yeni gelişmesi nedeniyle, Batı Anadolu'daki Geç Tunç Çağı ile Hellenistik-Roma metal işçiliğinin tarihi arasında bir boşluk vardır. Metalurjik yöntemlerin çoğunun Antik Yunanistan'a Kıbrıs ve Levant yoluyla geldiğini baz alan eski varsayımın aksine, Batı Anadolu'dan gelen arkeolojik kanıtlar, bu tekniklerin Ege'de halihazırda mevcut olduğunu göstermektedir. Gordion, Klazomenai ve Sardeis gibi

Batı Anadolu'da hem Tun Çaęı hem de Demir Çaęı katmanlarına sahip birçok antik yerleşim, materyallerinin kesintisiz bağlantısı vesilesiyle iki dönem arasındaki metal işleme teknikleri arasında bağlar kurmak için zengin bir veri kaynaęı sunmaktadır. Bu tez, çoęu zaman belirli metal işleme teknolojilerinin ve hatta elementlerin kökeniyle ilişkilendirilen Lydia, Mysia ve Phrygia bölgelerindeki halk hikayelerini keşfederek, bölge sakinlerinin mineraloji algısını ortaya çıkarmayı amaçlamaktadır. Sonuç olarak Batı Anadolu filozoflarının ve mitolojisinin tasarılarının izleri, Aristoteles üzerinden görüldüęü gibi Antik Yunan bilimsel mirasında da görülmektedir. Bu araştırma, Batı Anadolu metal işçilięinin Antik Yunan'ın bilimsel mirası üzerindeki önemli etkisini hem teoride hem de pratikte vurgulamaktadır. Ek olarak, Batı Anadolu metal işçilerinin yaptıkları işle ilgili teorik bir kavrayışa sahip oldukları ve potansiyel olarak kendilerini zanaatları aracılığıyla bilginin koruyucuları olarak tasvir ettikleri öne sürülmektedir.

Anahtar kelimeler: Arkeometri, metal işçilięi, batı Anadolu, M.Ö. ilk binyıl, mitoloji

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CHAPTER 1

INTRODUCTION

1.1 Statement of the Research Question

The main intention of this thesis is to display the technological level of metalwork in western Anatolia (as displayed in Map 1) during the 1st millennium. Anatolia has been the subject of archaeometallurgical research for many decades (for a brief research history, see: Chapter 2). While there are more studies on metallurgical technology in western Anatolia for the Bronze Age, the metallurgy in the same area during the first millennium BC is comparatively a rather barren field of study. Compared to the material evidence for industrial activities from other regions, particularly the central and eastern regions of Anatolia, the technical level in western Anatolia during the 1st millennium has yet to be discovered. This is mainly due to a scarcity of publications and artifacts relating to metal workshops, as well as a lack of adequate investigations and excavations in the region (Cevizoğlu & Yalçın, 2012: 73). The traditional perspective has tended to view Cyprus as the intermediary between Eastern Mediterranean and Aegean technological innovations. Due to the emphasis on Cyprus, the Levant, and eastern Anatolia as metallurgical innovators, the Aegean has seen relatively little interest in this question so far (Mokrišová & Verčák, 2022: 138). In contrast, recent discoveries in the Aegean, Greece, and Italy have enlarged the knowledge of metalworking associated with Iron Age workshops (Cevizoğlu & Yalçın, 2012: 73). The purpose of this study is to constitute a general

overview of the metallurgical variety of metalwork in western Anatolia around the mid-first millennium BC based on the archaeological record and to shed light on the identity of the metallurgists from the same period and region. If there are conspicuous patterns among the chemical compositions of item groups with unusual alloys, they will be compared to other Classical or Hellenistic metalworking technologies. In the case of them being made through techniques considered unknown for their contemporary period, this would suggest two possibilities: those techniques were either more common than previously accepted, or secret traditions. Thus, the thesis aims to establish connections between the metallurgical techniques used by the ancient civilizations of western Anatolia vis-a-vis their possible grounding in philosophical deliberations. Ultimately, both the actual level of metalwork and scientific knowledge in practice within the scope of western Anatolia in their relation to indigenoussness can be clarified.

I chose western Anatolia due to its proximity to two distinct cultural environments from which it may have both provided and received knowledge. The wealth of Lydia and the workmanship of Phrygia are reported in many of the classical sources (Andreeva, 2020: 60). Moreover, the city-states of Ionia are considered the birthplace of natural philosophy, which later paved the way for the natural sciences. Although both the Ancient Greek and Roman sources agree on the fact that much of their metallurgical tradition has roots in these places (Plin. *Nat.* 7.57; Hdt. 1.94; Paus. 10.16.1-2), the question of “to what extent?” remains unanswered. Explaining how organic and continuous this flow of tradition has been throughout history will aid in revealing the coastal and inland Aegean's integral role in shaping not only this particular branch of human achievement (i.e., metallurgy), but also classical history.

1.2 Outline of Thesis

The whole of this thesis is divided into seven chapters.

Chapter 1 introduces the methodology and theoretical framework employed.

In Chapter 2, the discussion delves into the definitions, limitations and potentials of spectrographic analyses, shedding light on the techniques used to examine the composition and properties of metals in archaeological contexts.

Chapter 3 provides an examination of the geographical scope and boundaries of the study. It delves into the specific regions and areas under investigation, considering their historical and cultural significance. Additionally, the section explores the geological formation of these regions, highlighting how the natural environment and geological features have shaped the development and distribution of metalworking traditions over time. Chapter 4 subsequently focuses on the alloying traditions prevalent in ancient times, providing an overview of the various methods and techniques employed in metallurgy.

Chapter 5 explores the history of the region, philosophies and the folk tales perceived by the inhabitants of western Anatolia during the first millennium BC. It explores the cultural and social context in which metalwork and metalworkers operated, highlighting the beliefs, stories, and literary traditions that shaped their practices and perceptions. Chapter 6 displays the distinctive and unusual types of metalwork found in selected regions. It presents the unique characteristics, techniques, and styles of metalworking specific to these areas. Chapter 7 evaluates all the data in accordance

to history, folklore and philosophical concepts and offers new insights to western Anatolian metalwork.

1.3 Purpose of Thesis and Methodology

The phenomenon, controversially called the “Greek miracle,” might indeed be one of the most influential cultural breakthroughs in the Mediterranean world. The term itself describes the outstanding artistic, literary, and scientific accomplishments of Ancient Greece between the fifth and fourth centuries BC, and was coined by the German classicist Friedrich Nietzsche (1872: 33). This view has rightly been challenged by scholars who argue that many other cultures (mainly Near Eastern) made significant contributions to human knowledge and civilization that have been overlooked or undervalued¹. Nevertheless, despite the undeniable bias resulting from the Eurocentric history writing of the 19th century AD (Netz, 2020: 2), the written records focusing not only on art but also crafts and the natural sciences behind them from the Classical Age have indeed witnessed a significant accumulation of intellectual knowledge in Ancient Greece, shortly after a period called the "Greek Dark Age" by historians (Lemos, 2006: 87). To further clarify this issue, the concept called "The Axial Age," proposed by Karl Jaspers in 1949 provides valuable insights. According to Jaspers, the Axial Age was a period of great systematization of ideas that occurred between the 8th and 3rd centuries BC and was characterized by significant changes in human thought and culture (Bellah & Joas, 2012: 2). Jaspers demonstrated that various forms of knowledge and ideas had already existed

¹ *Black Athena: The Afroasiatic Roots of Classical Civilization*, by Martin Bernal, was the first major work to challenge this tradition. The book may be out of date, but it sparked a heated discussion about the "authenticity" of ancient Greek civilization among ancient historians.

throughout the world since the earliest times traceable by means of writing, but that it was not until the middle of the first millennium BC that these disparate ideas began to coalesce into more structured schools of thought (Bellah & Joas, 2012: 2). That is why during this period, many of the works today labeled as "classics" were written. What followed the "Classical" era of inquiries was the grand campaign of Aleksandros III of Macedon against the Persians (from 336 BC to 323 BC.). The subsequent reign of the successor Macedonian kingdoms throughout Greece and the Near East allowed the inhabitants of both regions to access each other's accumulated knowledge (Jones, 1991: 443). The succeeding generations continued to study the scientific heritage established in the Eastern Mediterranean, primarily in the Roman and Byzantine Empires (Vogel, 1967: 267), then during the Islamic Enlightenment, and finally in Europe (especially after the Renaissance). However, this legacy, often referred to as "Hellenistic" (Whitmarsh, 2018: 5), is far from being a Big-Bang-like explosion that occurred immediately after the Greek Dark Age. As was stated above, this accumulation had an aftermath in which it would become a legacy, just as it had a *past* that allowed it to accumulate. However, how this past (which will be discussed in this thesis within the context of metallurgy) is reflected in written culture and folklore and reveals itself in archaeological material remains subject to controversial debate.

A cliché about Anatolia is that it has always been "a bridge between East and West" (Yener, 1995: 119). In this context, the past scholarship had tended to see Anatolia as a middle ground that only received foreign innovations. However, the evidence currently available unequivocally demonstrates that metal items crafted in various parts of Anatolia were locally produced or indigenously manufactured (Lehner &

Yener, 2013: 544). Even before the aforementioned Greek miracle, Anatolian civilizations were dealing with metallurgy experimentally. They mastered the basic procedures of extracting metals from polymetallic ores very early and thus altered them through special cementation techniques. Both *daimonoi*² in Ancient Greek folklore -who were believed to have brought the metal-related mysteries to the West and the Presocratic philosophers lived in this region. While Aristoteles was the former of the basis of the Ancient Greek scientific knowledge, the actual roots of the questions he pursued were the Presocratics (Solmsen, 1958: 278). In order to understand the deep history of the development of metallurgy in Anatolia, it is necessary to compare the written records pertaining to metallurgy with archaeological material on a site-by-site basis. The most significant outcome of such an investigation would be that the metalworking tradition in Anatolia continuously developed from the Early Bronze Age up until the so-called Axial Age or the Greek miracle and only then became visible in historical records.

1.3.1 “Science” in Antiquity

In pursuing this, a relativist approach to the definition of “science” is considered essential. Since the ancients did not have a positivist sense of science which is divided into categories according to their empiricist methods (namely chemistry, physics and biology), many of the ancient philosophers conducted their studies as polymaths (Lloyd, 2012: 214). In this regard, instead of gravitating towards a single faculty, they gained knowledge of a variety of disciplines. Furthermore, their

² *Daimonoi* were beings between gods and mortal men in Greek mythology. They were able to use supernatural powers but did not have supreme powers like the major gods. They can be seen as mediators between the mortal and divine realms (Pachoumi, 2013: 47).

approach did not depend solely on material qualities. Instead, they mingled them with divine cosmology, thinning the veil between the physical and the metaphysical. Aristoteles, who later became almost the sole authority on natural phenomena (Telelis, 2020: 191; Çetinalp, 2022: 1), asserted that all the elements have a natural place in the cosmos and can be merged into an ultimate substance, for instance (Aristot. *Meteor.* 1.35). This sense was first mentioned in his *Physika*, where he is occupied with explaining the order of nature as a continuous process of fusion (Aristot. *Phys.* 2.10). Describing nature as a constant change and assuming every element is connected both to each other and divinities led the ancients to contemplate transformations. Metallurgical transformations, the actual scope of this study, involved various magic and ritual expressions (Blakely, 2006: 3). The Stockholm and Leyden *papyrii* shed light on the technological level in the Roman world of the 3rd century AD and were later accepted as alchemical sources (Caley & Jensen, 2008: 3), displaying how “esoteric” chemistry could be. Many of the recipes in these *papyrii* can be found in Pseudo-Demokritos (Martelli, 2013: 6), which brings one once again to western Anatolia. The authorship of this work is anonymous, but it is asserted that Bolos of Mendes, who resided in Hellenistic Egypt, was one of the authors (Martelli, 2013: 47). Nonetheless, it can be argued that Demokritos played a role in shaping this tradition, as evidenced by the philosophical methodology employed in the texts and the prevalence of certain substances in Anatolia.

Due to the ancient world's perception of nature, attempting to comprehend their efforts to alter matter through philosophical undercurrents will be beneficial. The manner in which they understood nature may reflect how they shaped it.

Consequently, certain ancient experimental approaches to matter/minerals involving

the prevailing traditional knowledge of their time cannot be easily explained by our "positivist" perspective on color or quality-enhancing measures but require insight into their contemporary and emic views, approaches and perspectives. The same approach can also give clues about interactions between the Aegean and Near East, displaying the level of "indigenoussness" of techniques. Since there was no "science" in the modern sense but philosophy as its predecessor in this period (Lloyd, 2012: 213), the theoretical scope of this thesis is mainly based on natural philosophers who can be characterized as pursuing the "revered knowledge" (Lindsay, 1970: 103) that could only be achieved by a certain privileged elite. Certain aspects of this "revered knowledge" might resound to some extent in relevant folklore and will be examined philologically. In this regard, I transliterated the Ancient Greek and Latin names in this study according to their original forms rather than the English versions. A case in point is the preference of "*daimon*" over "demon," for the latter implies a necessarily evil meaning which appeared only after 1712 (Online Etymology Dictionary, n.d.).

In order to see the actual material manifestation of the aforementioned dissemination of knowledge, spectrographic data from the selected metal objects excavated at sites located in my model regions from western Anatolia (Sardeis, Daskyleion and Gordion in particular) will be subject to debate. My main criterion is to examine how much the items have changed compared to their usual chemical composition. By "usual," emphasis is placed on the modernly accepted percentages for alloying ratios in ancient objects. Thus, it will eventually be possible to deduct how familiar the ancients were with the structure of matter and how much their techniques could alter it in the context of approaches we would nowadays categorize as "applied physics."

1.4 Theoretical Framework

The major objective is to spot unusual items in regards to their chemical composition from mid-1st millennium western Anatolia. Within the scope of this thesis, the presence of lead (Pb) and zinc (Zn) with high percentages are considered of special interest for they demonstrate the presence of atypical metalworking methods for the mid-1st millennium BC. However, one of the difficulties of interpreting the results of archaeometrical investigations is the possibility of changes in the chemical composition of the studied material up until the present day. To be more specific, changes in element ratios as a result of its recycling over time can make it challenging to identify a material as a deliberate alloy. Ores like copper in nature always contain traces of other elements, and reaching only certain percentages is considered to be an intentional alloy. The definition of an intentional alloy remains subject to debate. Still, recent studies on Anatolian metalwork and Late Bronze Age metallurgy suggest that an alloy must contain at least 3% lead (Pb) and at least 1% tin (Sn) to be considered intentional (Lehner, 2017: 250). Lately, a minimum weight percentage of 8% zinc (Zn) is suggested for artifacts to be identified as purposely made brass (Morton, 2019: 4; 7). Evidence for the intentional alloying of lead and zinc with other elements (especially bronze) before the Roman Imperial age is uneven (Waldbaum, 1983: 171; Craddock, 1978: 1) and has only recently begun to be considered in terms of possible large-scale production. As a result, the presence of zinc and lead in these materials has often been overlooked or considered coincidental (Caley, 1970: 39; 41; Craddock, 1978: 4).

Nonetheless, I will argue why the presence or absence of these elements needs to be handled with greater care and offer suggestions for how they could have their own

“industries” during the middle of the first millennium BC. These experimental initiatives rely heavily on the similarities between these metals and gold (Au) and silver (Ag), as well as the importance of the precious metals silver and gold in ancient economies. I intend to compile all archaeological research and data pertaining to the use of the metals above in western Anatolia during the middle of the first millennium. As this is a relatively unexplored field, however, there has been little scientific analysis of the material discussed so far (Cevizoğlu & Yalçın, 2012: 73; Craddock, 2003: 217) Nevertheless, the absence of analysis does not imply that the classical sciences, such as philology and history, cannot contribute to the debate.

This thesis employs a method to apply methodologies used by classical sciences beyond a purely processual perspective to make the statistically invisible visible through the humanities fields like philology and ancient philosophy, and to develop a technical scheme that future analyses can verify. In this regard, the history of western Anatolia is examined with a Braudel approach, considering the geological formations and their influence on metalworking practices. In addition to archaeometry and history, the philosophical texts and folkloric narratives pertaining to the region and time period are evaluated, shedding light on the intersection of philosophy and metalwork. Ultimately, within the scope of this thesis, a threefold alternative methodology (based on archaeometry, history and philosophy) is formed to interpret the metal items with irregular alloys in western Anatolia with a relativist approach that takes the perception of the ancient people into consideration.

CHAPTER 2

ARCHAEOMETRY

2.1 Definition

Archaeometry (from ἀρχαῖος [ancient] and μέτρον [to measure] in Ancient Greek; (A Greek-English Lexicon, 1940)³ is the application of scientific methods to the analysis of historical or archaeological materials and artifacts in order to gain insight into the technological, social, and cultural practices of past societies (Rehren & Pernicka, 2008: 238). In the middle of the 20th century, with the advent of new technologies such as X-ray fluorescence, diffraction, and atomic absorption spectroscopy, archaeometry expanded to include not only metals but also other categories like glass and pigments. As further analytical techniques such as laser ablation, inductively coupled plasma mass spectrometry, and scanning electron microscopy were developed in the 1980s and 1990s, the field continued to grow. Using these techniques, scientists are able to analyze materials on a much finer scale and gain insight into the manufacturing processes and working methods of ancient craftspeople. For our case, employing and defining only specific techniques for analyzing the metal's elementary composition and establishing its provenance will be

³ As a name, Christopher Hawkes from Oxford invented the term archaeometry in the early 1950s to describe the emerging significance of absolute dating, physicochemical analysis, and quantitative methods in archaeology. In the late 1950s, Archaeometry was first officially used as the title of an international journal (Liritzis *et al.*, 2020: 51).

sufficient. Only the descriptions of the methods utilized for the analyses of the data presented in this study are provided in the following section (Chapter 2.3.1) and techniques for dating are excluded.

2.2 Ancient Methods for Assessing the Authenticity of Metal Items

An archaic sense of “archaeometry” existed regarding physical or chemical approaches to matter during classical antiquity. It was primarily limited to verifying or falsifying the authenticity of precious metals, especially in the form of coins (Oddy, 1983: 52). Oddy (1983: 58) even asserts that the methods utilized by Ancient Greeks 2500 years ago are the ancestors of modern chemical analysis. In their overview of archaeometry, Liritzis *et al.* (2020: 51) assert that alchemists, who may be defined as conjurers who sought to transform elements into each other, and 19th-century scholars have all observed and dealt with natural phenomena and that these early observations which have started in the Renaissance and continued until the 19th-century scientific scholarship may be considered the basis for archaeometry or the first analyses of wet chemistry in archaeological materials since the Renaissance. Nonetheless, if the central role alchemy played in the development of modern archaeometry is recognized, the history of mankind's investigation (and manipulation, consequently) of the physical and chemical properties of metals stretches back to considerably earlier times.

I will first consider coin counterfeiting as an ancient form of alchemy. It was developed at roughly the same time as coinage itself (Waldbaum, 1983: 7). As hoards are one of the primary ways that ancient coins are uncovered, and as those who buried them only intended to save the most precious coins they could find, the

possibility of forged coins surviving until today is surrounded by uncertainty. Nevertheless, evidence from antiquity suggests that this was a major problem at the time (Oddy, 1983: 52). Consequently, caution was necessary because there were always people with access to knowledge systems that allowed them to imitate the appearance of precious metals. For instance, forgers would cover less valuable metals with a thin layer of gold or silver to make them appear more valuable through a process called gilding (Oddy, 1983: 52). In order to imitate the shiny appearance of the two metals, they could do the same with copper (Cu) or brass (Cu-Zn), too.

Fire Assaying

One of the oldest methods to solve the issues of faked metals was fire assaying. Among the fundamental stages of fire assaying is the addition of surplus lead to the gold, which is then melted in a specially designed crucible under the influence of an oxidizing flame. During this process, the lead and other alloying components, excluding silver, are oxidized and form a slag, which is absorbed by the ceramic crucible, leaving behind the gold and any accompanying silver (Oddy, 1983: 54; Plin. *Nat.* 33.19). This method is destructive, as the gold was melted and mixed with other substances.

Touchstone Method

Another method involved using a special black stone (lydite or slate) to compare the color of the metal artifact with known samples of gold and silver. The touchstone method was non-destructive, requiring a trained eye to accurately identify the metal

(Caley & Richards, 1956: 154; Plin. *Nat.* 33.43). Through a modern colorimetric assessment, Manas (2021: 7) concluded that its accuracy could be really high.

Gravity

The last method was the use of gravity, the discovery of which is attributed to Arkhimēdēs. He understood that gold (19.3 g/cm³) was heavier than silver (10.5 g/cm³) and more than twice as heavy as copper (8.9); therefore, comparing the weights of the metals would reveal their authenticity (Oddy, 1983: 55).

These methods, especially fire assaying for it included cupellation and cementation, which will be explained in the later stages in this thesis, were an important part of ancient metallurgy, and their legacy can still be seen today in modern techniques for testing the authenticity of precious metals (Oddy, 1983: 58).

2.3 History of Modern Archaeometry

History of modern archaeometry dates back to the 18th/early 19th century when scientists began employing chemical and physical methods to analyze archaeological materials such as pottery, metals, and glass (Watchman, 2015: 1). Initially, this was primarily restricted to ancient economies, such as the waning and waxing value of the currency and the recurrent devaluation of coinage. As a result, this would later lead to a better understanding of ancient societies' trade networks and technological practices (Rehren & Pernicka 2008: 236). Today, the actual value of spectrographic examination for metal analysis is to define and classify different alloys used in the casting process, as well as to trace changes or new adaptations to alloying traditions

over centuries or millennia. The techniques employed at the time were comparable to those of antiquity and can be named docimology which is a concept aiming to assess the amount of precious matter in non-precious (solid) substances.

Martin Heinrich Klaproth introduced a revolutionary concept in 1800 when he conducted a destructive analysis on an ancient Greek coin to determine its actual composition in order to assess the economy of the time (Caley, 1949: 268). Table 1 displays how accurate the percentages he found were when compared to a relatively modern chemical analysis (Table 1). In 1842, Göbel advanced the field further by making the inquiry on how to determine the lifeway of people from whom they derive (Pernicka, 2014: 239). For the inquiries related to the provenance of metal objects, even then, minor elements had been found more useful in determining the nature of the ore from which the metal was extracted (Pernicka, 2014: 239). It was understood that compositional differences between copper metals could be expected when native copper, oxide, or sulphidic ores were smelted. Around 1930, atomic emission spectrometry was utilized to detect a substantial percentage of trace elements in samples as small as a few milligrams (Pernicka, 2014: 240). This was followed by W. Witter's systematic studies of ancient metals in 1931 (Pernicka, 2014: 240). The absence of a consistent chronological framework for all of Europe and the lack of computer technology capable of handling such large datasets posed the most significant challenges of the time (Pernicka, 2014: 247), for there were no available interlaboratory comparisons or internationally recognized reference materials for laboratories to use to compare their results (Pernicka, 2014: 244).

Lead isotope analysis prompted the revival of provenance analyses (Pernicka, 2014: 247). It was at first applied to lead (Brill & Wampler, 1965) and silver (Gale, Gentner & Wagner, 1980) and then finally to copper and copper-based alloys (Gale & Stos-Gale, 1981a). The use of novel analytical techniques proved to be more sensitive and accurate than the previously dominant optical emission spectroscopy (Pernicka, 2014: 247).

The application of archaeometry to the study of cultural heritage in Turkey dates back to Karl Ernst von Baer's (1876) (Oppenheimer, 1990: 81) investigation into the elusive tin of antiquity. In the early 1900s, valuable contributions were made to the study of ancient Anatolian metalwork. Due to Wilhelm Dörpfeld and Heinrich Schliemann's excavation activities, Hubert Schmidt was able to perform and publish the first analysis of the chemical composition of Troia artifacts (Schmidt, 1902). H. R. Karajian (1920) and S. Przeworski (1939) have written comprehensive analyses of Anatolia's mineralogy and metalworking techniques. Ufuk Esin incorporated lead isotope analyses into the archaeological work in the 1960s (Esin, 1969), thereby expanding the scope of archaeometry in Turkey. Moving into the present day, in the field of metallurgy and its relationship to raw materials, a number of scholars have made indispensable contributions to our understanding of early Bronze Age metallurgy in the Aegean and Anatolia, which will be discussed in the following.

Particularly, the early investigations of de Jesus (1978), as well as the campaigns of Wagner and Öztunalı (2002), which complemented and corrected the outdated parts of the first source, have been utilized as primary sources. For the case of Early Bronze Age metallurgy in Anatolia, the contributions of Pernicka, Eibner, (again)

Öztunalı, and Wagner (2003) are of vital importance for they presented the potentials of ancient mining activities in the given region. Lehner and Yener (2013) have been the primary sources for understanding the organizational structure and specialization of early mining technologies in Anatolia. For the theoretical framework of this thesis, Thomas Zimmermann's (2016) research on the technological and social aspects of metal use in early Anatolian societies is most valuable. Waldbaum, who authored a valuable monograph on Lydian metalwork (1983), and Craddock (2003), who conducted an intriguing investigation on ancient Anatolian zinc objects, have made possible Chapter 6 of this thesis. Together, these scholars have provided significant insights into the history of metallurgy and mining in the Aegean and Anatolia, thereby enhancing our understanding of the earliest societies in this region. Yet, again, the classical metalwork of the 1st millennium BC stands as a gap between the Bronze Age and the Roman Imperial Period. In recent years, archaeometry has remained a crucial method for studying the archaeology and cultural heritage of Turkey. Thus, remarkably competent metal analysis studies, primarily on the Early Bronze Age but also on the prehistoric periods of Anatolia, continue to expand our understanding of social structures. The purpose of this thesis is to draw conclusions about the Iron Age, which was wedged between the once incomprehensible Bronze Age interregional network and the zenith of Ancient Greece and Rome.

2.3.1 Methods for Characterization and Provenancing

There are two types of methods utilized for analyzing metals: destructive and non-destructive. The destructive approach demands mechanical sampling of the object to reveal alloy, while the non-destructive ones use X-ray surface scanning to extract the object's elementary composition. Only the pioneering techniques and those with

references in case studies are described below and methods for precise dating are excluded.

X-ray fluorescence spectroscopy (XRF) and Portable X-ray fluorescence (pXRF)

X-ray fluorescence spectroscopy is a -mostly- non-destructive method used to analyze the elemental composition of a metal object. This method can provide information about the provenance of a metal object based on the trace elements present (Kolb, 2014: 6179). In XRF, exciting a sample with high-energy X-rays causes the sample to emit secondary X-rays. The energy of these secondary X-rays is distinctive of the sample's elements, allowing for their identification and quantification. Portable X-ray fluorescence (pXRF) is a practical innovation that allows researchers to do the analysis through a mobile device (Shugar, 2013: 174). Portable XRF spectrometers are especially advantageous for analyzing large or fragile objects that cannot be transported. It is the most prominent and widely used technique for provenancing studies due to its practicality.

Lead isotope analysis

Lead isotope analysis involves measuring the isotopic composition of lead in a metal object to determine its source. The majority of elements consist of numerous isotopes, or atoms with very similar chemical properties but differing masses. (Pernicka, 2014: 247). Thereby, the molecular weight of compounds containing low-atomic-number elements can vary considerably. This results in slightly varied isotopic compositions in different reservoirs from different geographical regions

(Pernicka, 2014: 247). In contrast, elements with a high atomic number typically exhibit no measurable isotope fractionation in their natural environment (Pernicka, 2014: 247). However, certain elements, such as lead, comprise part of radioactively decayed isotopes. If lead is not mixed from varying sources, it is extremely unlikely that the lead isotope ratios will be altered by any of the physical and chemical processes that occur during the metallurgical process from ore to finished product. (Pernicka, 2014: 248). The majority of the same arguments apply to lead in copper deposits; therefore, lead isotope analysis can also be applied to metal objects composed of copper (Pernicka, 2014: 247). Consequently, lead isotope analysis can give the chemical signature of the ore from which the metal object was made.

Metallography

The study of the physical structure and elements of metals is known as metallography, and it frequently makes use of (electron) microscopy. A metallographic specimen's surface is prepared using a variety of grinding, polishing, and etching techniques during the process. The sample is examined using optical or electron microscopy after preparation. A knowledgeable specialist can distinguish alloys and predict material qualities using just metallographic methods (di Gianfrancesco, 2017: 197). Working methods like cold-hammering, annealing and casting can be determined through metallography.

Neutron activation analysis (NAA)

Neutron activation analysis (NAA) involves exposing a sample to neutrons, which induces nuclear reactions with the sample's atoms. Resulting nuclear reactions are accompanied by the emission of detectable gamma radiation, whose energies can be measured to determine the specific nuclear reaction(s) occurring and to identify the elements present in the sample. Thus, NAA techniques generate the "chemical fingerprint" of a sample (Glascock 2014, 5239).

Positron emission spectrography (PET)

The technique of positron emission spectrography (PET) involves heating a sample to a high temperature until it emits light. The light is then analyzed to determine the chemical constituents of the sample. This method is especially useful for analyzing metals like copper and bronze (Worden, 2005: 64).

Atomic absorption spectrometry (AAS)

Atomic absorption spectrometry (AAS) is a technique for determining the concentration of certain elements by passing light through a sample. When light passes through the sample, the atoms of the present elements absorb a portion of its energy. By measuring the amount of energy absorbed, it is possible to determine the concentration of the elements. This method is especially useful for analyzing trace elements like lead and zinc (Bower, Bromund & Smith, 1975: 389).

X-ray fluorescence spectroscopy, lead isotope analysis, metallography, neutron activation analysis and atomic absorption spectrometry are among the methods used

to examine the material presented (in Chapter 6) from the model regions of this thesis.

2.3.2 Current Issues

Archaeometric methods, of course, are not without limitations and difficulties. The actual condition of a sample and its preparation is crucial for any metal analysis. The instance of remelting and using such metals can lead to misinformation for the researcher.

Corrosion, which is caused by soil conditions and, frequently, inadequate storage conditions, causes significant chemical and morphological changes in metallic objects and their constituents. Non-destructive methods are generally limited to examining objects' patina-coated (or corroded) surfaces. Patina has a distinct elemental composition compared to the metal it adheres to, and its composition changes over time. The formation of the patina impacts the elemental signature of the alloy in multiple ways, including by altering its surface structure, which is influenced by the factors mentioned (Emmitt & Mcalister & Armstrong, 2021). For instance, corrosion that comes with recycling causes the prominent elements to change in rate: Iron's ratio decreases when copper is recycled/remelted (Pernicka, 1999: 165; Emmitt *et al.* 2021: 3) In contrast, the ratios of other potential copper-related alloying agents (or natural impurities) such as arsenic (As) and antimony (Sb) increase in tandem with repeated remelting cycles (Pernicka, 1999: 165). So, it can be challenging to estimate the analyte actual concentrations precisely if the sample matrix contains patinas that glow at the same wavelengths as the analyte substances. The small size of

the detectors (in pXRF analysis) restricts their efficiency, resulting in low geometric and intrinsic efficiencies, especially at high energies (Ferretti: 2004).

Regardless of the ratio, lead's isotopic composition is constant. The isotopic composition of lead from various provenances is subtly different from one another. So, one must analyze and be familiar with each ore in order to find it. In addition, despite the fact that the variation of lead isotope ratios in ore deposits is much smaller than that of trace element concentrations, it is possible that another deposit possesses the same isotope ratios (Pernicka, 2014: 250).

Last but not least, another important scenario for this particular thesis is related to zinc. Electrochemical surface cleaning, preferably done in the 1960ies and 1970ies, may account for unexpectedly high Zn peaks in metal analyses. (Pernicka, 1990: 56). It is known to have been practiced on objects in Northern Central Anatolia (Geniş & Zimmermann, 2015: 284-5).

Antimony isotopic analysis and its potential for western Anatolia

Antimony isotopic analysis was considered unsafe for determining the origin of materials with a high Sb concentration. When using isotopes for provenancing, the signature must not change or do so in a predictable way between the source and the finished result. Heat is used in the processing of ancient metals and glass, which can result in fractionation, a shift in the isotopic ratio as a result of some elements partially evaporating or oxidizing (Dillis *et al.* 2019: 100). Sb has not been studied in ancient contexts as extensively as other metals, so new experiments are being

conducted to determine if it is present during laboratory sample digestion and pyrotechnological processing before Sb isotope ratio analysis is performed to compare ores to early metals and glass. The article by Dillis *et al.* (2019) covers the broad implications for the interpretation of Sb isotope compositions and provides evidence from laboratory experiments on the fractionation of stable Sb isotopes during the conversion of stibnite to Sb oxide. The investigations show that isotopes may be corrected for fractionation, utilized for provenancing, and can distinguish between anthropogenic and natural sources, potentially providing information about early antimony production and smelting processes. The paper also calls for further research on the link between fractionation and reducing antimony (Dillis *et al.* 2019: 110). Further research on Sb isotope analysis could potentially shed light on the use of lead and antimony in antiquity, particularly in the first millennium BC. Lead and antimony are not the same chemical elements since they have different characteristics and atomic configurations. Yet, it is true that antimony minerals like tetrahedrite or jamesonite can occasionally include lead. This is due to the fact that these minerals frequently contain a number of different elements, such as lead, antimony, copper, and other metals. While lead and antimony isotopic analyses are frequently carried out separately in archaeological contexts to determine their respective sources, it is also crucial to take into account the possibility of the intersection or co-occurrence of these elements in certain minerals or artifacts. Such an innovation can principally be productive for isotope analyses conducted in western Anatolia as antimony was used as a main alloying agent due to its easy accessibility from the abundant rivers present in the region.

2.4 Discussion

Archaeometry describes the various ways in which people interact with their environment as well as the wide range of socioeconomic activities. As a result, it can be described as a method of surveying ancient technologies through modern ones. In some ways, the application of science to archaeology is both a benefit and a curse. After the revolutionary developments in natural sciences in the 21st century, it was only natural for archaeologists to use this light to interpret the past better. In this field, "precision" appears to be a threat, even though it is questionable to what extent it can be accomplished. The discrepancies between previously accepted "facts" and the precise data available now raise more problems than they do solutions. Hence, when scientific research confirms the historical account, it is a blessing; nevertheless, when the reverse occurs, we find ourselves in a cumbersome situation. If someone admits to having no knowledge about a particular subject, they are starting from scratch. However, if someone has been given incorrect information in the past and operates on that assumption, they are already at a negative starting point. The labor suddenly becomes even harder than it was at the beginning, which is why it might be compared to a curse. Two case studies on spectrographically examined Lydian coin hoards will illustrate the issue in depth.

Even though the existence of a technology of separating gold and silver even before the time of Gyges has recently come to light (Alfen & Wartenberg, 2020: 5), which contradicts the previous assumption that the first Lydian coins were minted at a relatively later date, chemical tables of some Lydian coins published by Bolin and Paszthory in 1958 and 1980 had already indicated that those coins were chemically altered, with the reign of Alyattes serving as their *terminus ante quem*. The amount

of silver was higher than the natural electrum in Pactolos River -which is 70–80% gold and 20–30% silver (Alfen & Wartenberg, 2020: 4). In both cases, the two researchers had different explanations. As Waldbaum (1983: 7) cites, While Paszthory⁴ assumed it had to be natural, Bolin⁵ proposed something critical. He suggested that the addition of silver goes back to the first coinage, and thus, the state made a profit from the refinement, and even refinement could have been the incentive behind the invention of coinage. Although it was a bold statement then, the data available now proves it right.

In the end, anyone researching this area might find inspiration in the aforementioned dilemma about the “facts” and unusual discoveries. This is where archaeology should merge humanities and natural sciences. If read carefully, classical testimonies give an immense amount of clues that can be verified with the right archaeological methods.

⁴ See: Paszthory, E. (1980). Investigations of the Early Electrum Coins of the Alyattes Type. In D.M. Metcalf & W.A. Oddy (Eds.), *Metallurgy in Numismatics 1*, (pp. 151-56), London: Royal Numismatic Society.

⁵ See: Bolin, S. (1958). *State and Currency in the Roman Empire to 300 A.D.* Stockholm: Almqvist and Wiksell.

CHAPTER 3

GEOGRAPHY

3.1 Borders of the Model Regions

Geology and geography are crucial components of archaeology, particularly for archaeometry. I limited the geographical extent of our survey to the ancient regions of Lydia, Mysia and Phrygia (Map 2). This decision is motivated by their geological features and their reflections in literary evidence. Through folk tales that are transmitted through ancient historians and geographers, it is plausible to state that the ancient Aegean world had views about the origins of metallurgy and was aware of the regional origins of their metallurgical techniques. To demonstrate this, a few examples should suffice at that point. *Kabeiroi*⁶ and *Daktyloi*⁷, the *daimonoi* that were associated with metallurgy, were believed to have come from Mysia (Blakely, 2006: 14). The two *daimonoi* that were thought to have brought the mysteries about metals had come from Phrygia (Call. Fr. 113e). The myth of a river where gold flows by the intervention of a god is associated with Lydia (Ov. Met. xi. 90), which is also related to Phrygia, along with the spread of the common coin system in the ancient world (Hdt. 1.94). Each of these regions has distinctive geographic and physical characteristics that greatly impacted how they developed their history, economies,

⁶ The Phrygian *daimonoi* who were associated with metallurgy (Blakely, 2006: 13).

⁷ The Idaian *daimonoi* who were the consorts of Rhea (Blakely, 2006: 13).

and cultures. To trace this from written evidence, the weight is given to the ancient historians, geographers, and philosophers who either lived or traveled in western Anatolia. An outline of the region's physical properties, as well as its borders and frontiers, will be given in this chapter.

3.1.1 Lydia

Lydia is located in western Anatolia on the Aegean coast. The region is typically considered to be bordered by the Aegean Sea to the west, the River Hermos (Gediz) to the north, Mount Tmolos (Bozdağ) to the east, and the Maiandros River (Büyük Menderes) to the south (Roosevelt, 2009: 60). Lydia's terrain is heterogeneous; it consists of mountains, valleys, and plains due to its tectonic history which is labeled Menderes as metamorphism (Yılmaz, 1997: 40). Mount Tmolos, which borders the region's eastern boundary, is the most prominent mountain range (Roosevelt, 2009: 67). Particularly abundant in the region's mineral resources were its ores (Roosevelt, 2009: 89;), which had a significant impact on both its history and economy.

The most prominent mountain ranges in Lydia run east-west across the majority of the region's central and southern regions (Roosevelt, 2009: 67). Its most significant river is the Hermos (Gediz), forming the Middle Hermos River Valley (Gediz Vadisi), which contains the heartland of Lydia. Paktolos is the most notable of the various rivers that irrigate their valleys and border their mountains across the Lydian geography, which are among the defining characteristics. Kaistros (Küçük Menderes) and Maeandros are the most notable rivers in the southern regions (Roosevelt, 2009: 71). The lakes in this region, which comprise four natural lakes, the most important of which is Gygaie, were naturally fed by groundwater (Roosevelt, 2009: 72). The

topographic formation of these rivers and mountains is due to the immense Neogene faulting that began in the Miocene (Yılmaz, 1997: 50). There is a certain colluvial depression owing to high seismicity (Roosevelt, 2009: 75). All of these factors have contributed to the region's abundant natural resources.

3.1.2 Mysia

Mysia was situated adjacent to the Aegean Sea in the northwestern part of Anatolia. *Hellespontos* (Çanakkale Boğazı), Mount Ida (Kaz Dağı), the River Kaikos (Bakırçay), and the Aegean Sea formed the northern, eastern, and western boundaries of Mysia (Strab. 12.8), which also had a varied topography consisting of mountains, hills, and plains. This is because the effects of tectonics have shaped its appearance over time (Yılmaz, 2003: 63). Just as the rest of the Aegean stretches north to south, so do the grabens here, which run east to west. The significant morphological units, like the Ida Mountain, are post-Early Pliocene (Yılmaz, 2003: 71). Mount Ida was the most extensive mountain range in the area, and the lowlands of the River Kaikos and its tributaries were the most fruitful places to live. The region was rich in mineral resources, including silver, iron, and copper (MTA, 1971). The present study will focus on the Biga Peninsula.

3.1.3 Phrygia

Phrygia is predominantly characterized as a high plateau (Lahn, 1949: 91). The plateau is surrounded by mountain ranges, including the Anti-Taurus (Aladağlar) and Taurus Mountains (Toros Dağları) to the south, the Bozda Mountains to the west, and the Pontic Mountains (Kuzey Anadolu Dağları) to the north (Lahn, 1949: 91).

Though the boundaries of Phrygia were not precisely delineated, it was situated in the center of Anatolia (Strab. 12.8). The Salt Lake (Tuz Gölü) to the east, the Taurus Mountains to the south, the River Halys (Kızılırmak), and the Aegean Sea to the west can be taken as the broad borders of the region. Taurus in the south and Mount Dindymos (Murat Dağı) in the northwest made up the two most important mountain ranges. Mineral resources, particularly marble, and other building stones were abundant in the area. Several valleys and river systems divide the plateau, including the Halys River, the Sangarios (Sakarya) River, and the Maeandros River. Phrygia is located on the Anatolian Plate. The region also has a complex geological history and comprises numerous phases of rock formations.

3.2 Geology

It is simpler to draw more accurate conclusions about a region's role when one is aware of both the region's actual and potential capabilities in the context of its resources. It is known from the past that some archaeological investigations ignoring geological research have come to improbable conclusions: The Hittite expeditions to Arzawa, for instance, were interpreted by Jak Yakar as if they were about to seize significant mineral resources (Yakar, 1976). Yet, de Jesus' careful analysis of the ore deposits which the Hittites must have used in their heartland implies a different scenario (de Jesus, 1978: 97). In order to avoid such errors and to clarify the physical limits of the study, a brief description of the geology of western Anatolia is necessary. The classical testimonies about the same region shall follow. It will then become possible to contextualize historical landmarks by relating them to the overall geography of the relevant region.

3.2.1 Geology of Western Anatolia

The geographical region known as western Anatolia includes the southern Marmara Region, the entire Aegean Region, the western Mediterranean Region, and Eskişehir from the Central Anatolia Region. The main part of this thesis, the Aegean Region, is divided into two sections: the Coastal and Inner Aegean. The Turkmen and Emir Mountains are roughly where the Aegean Region begins, followed by Kaz Mountain, Madra Mountain, Simav Mountains, and Dominiç Mountain in the north, and Karakuş Mountain and Göreli Mountain in the south. The geological structure in this area of western Anatolia is worth describing in terms of context, even though examples from the aforementioned neighboring regions are also included in this study.

The Aegean lies between the African and Eurasian plate lines (Nur & Cline, 2000: 45). It is seismically a very active region. Due to the effect of the strains between north and south, horsts and grabens are the geological formations that are most frequently observed in western Anatolia (Yılmaz, 1997: 49). A graben is a depressed block of land that has fallen between two parallel faults (Hoogenboom Hagen, 2014), whereas a horst is an elevated block of land that has been uplifted between the same parallel faults (Giles, 1968). These characteristics are typical in fault zones and rift valleys, which are tectonically active regions. These formations caused mineralization along the horsts (Şengün, Erlandsson, Hogmalm, & Zack, 2019: 1), making them potential metal veins for the inhabitants.

In geological terms, western Anatolia is a relatively young region (Yılmaz, 1997: 50). Although the most recent formations were shaped after the early Pliocene (Yılmaz, 2003: 74), prior to those new tectonic activities, the volcanic alignment was responsible for the division of the lake basins (Aydar, 1998: 71). The intense volcanic activities decreased by the Middle Miocene, though there were tiny extinct volcanoes that used to occasionally erupt, according to ancient records.

Western Anatolia is under the pressure of many fault lines and is subject to the movement of various bedrocks (Yücel *et al.*, 2000: 355). In *The Development of Prehistoric Mining and Metallurgy in Anatolia*, de Jesus states that due to the presence of notably different characteristics, it is not feasible to consider this region as a singular entity (de Jesus, 1978: 45). While Lydia is underlain by two bedrock groups, namely the Menderes massif and the İzmir-Ankara Kenet Zone, Mysia and Phrygia are on the Sakarya Zone. The Menderes massif is located in the central, southern, and eastern parts of Lydia, consisting of various metamorphosed rocks such as gneiss, schist, phyllite, quartzite, and marble that date back to Precambrian or Late Paleozoic times (Roosevelt, 2009: 37). All the rock assemblages experienced extensive Neogene faulting that began in the Miocene due to crustal extension, creating a system that separated river valleys from highland and mountain ranges (Roosevelt, 2009: 37). This faulting mainly occurred in the valleys and mountainous regions of various rivers, resulting in the topography seen today. The spaces between these ranges and peaks are characterized by deep cuts made by the tributaries and upper reaches of the Büyük Menderes, Gediz, and Küçük Menderes rivers (de Jesus, 1980: 45). Quaternary formations include the Kula volcanics, which formed from basaltic cones and lava seeping through a mantle plume, and active magma chambers

that still cause geothermal activity in the area (Roosevelt, 2009: 38). The western region belongs to the Aegean plate, which is undergoing a different shift than the Anatolian plate. The lithosphere of the Aegean plate is expanding, resulting in cross-movement compared to the rest of the Anatolian landmass (Taymaz, Yılmaz & Dilek, 2007: 1). This movement not only causes the widening of Çanakkale Boğazı, Sea of Marmara, and Bosphorus but also isolates the Aegean plate from the orogenies of the Anatolian plate.

The region is rich in metal ores as a result of the region's geological formation process, as demonstrated by its relatively newly formed mountain ranges and intense seismic activity. The same situation must have allowed for the early development of metallurgical techniques in Anatolia, which has one of the oldest histories of the aforementioned craft (Yalçın, 2008: 17).

3.3 The Mineral Resources

The presence of ore within the Earth's crust does not necessarily make it easy to retrieve. Rather, it is the concentration and accessibility of the ore that matters. While copper can be found in large amounts in the soil and even in living organisms such as the human body, it is only considered valuable and usable when it is sufficiently concentrated (de Jesus, 1978: 50; Radivojević *et al.*, 2010: 2776).

Orogenesis, the process of mountain-building, has played a significant role in the formation of metal deposits around the world (Sawkins, 1990: 2). However, it is not the only factor responsible for the creation of these valuable resources. Magmatism,

hydrothermal activity, weathering, erosion, and sedimentation are all important geological processes that can contribute to the formation of metal ores (Sawkins, 1990: 12). Nevertheless, seismology is still a critical factor closely related to a region's metal wealth and metallurgy. The activity of a fault line can create a variety of geological features that are conducive to the formation of ore deposits. As mountains rise and fall due to tectonic activity, rock layers are subjected to intense pressure and heat, leading to metamorphism and the formation of new mineral structures. This process can lead to the formation of valuable mineral deposits.

The nature of the mineral deposits in western Anatolia is divided into three by de Jesus (1978). In the first case, the placer deposits, the process of erosion is responsible for separating heavy minerals from light ones by causing minerals of similar specific gravity to group together. In the event of a river bed drying up, these deposits may be covered by additional sediments, providing a protective barrier from further weathering. This natural phenomenon highlights the importance of sedimentary processes in the formation of valuable mineral deposits (de Jesus, 1978: 51). In the second case, the secondary enriched ores; it is stated that once erosion has taken place, metal ores that were previously hidden within the earth are exposed. However, the process does not stop there, as these exposed metal ores are still subject to further weathering (de Jesus, 1978: 51). For the third, the alluvial deposits, it is stated that when water erosion removes the surface earth and finds its way to a mineral deposit, the deposit can also be fragmented by the force of the water. In other words, erosion can expose and break apart mineral deposits (de Jesus, 1978: 52).

Since the 1950s, more than 136 deposits of complex lead-zinc-copper ores and 415 significant copper extraction zones in Anatolia have been identified. There are also over 200 silver-lead deposits (Muhly, 1973: 200). However, these numbers should be approached with caution. Among the earliest sources for the distribution of ore deposits in Anatolia come Ryan (1960), the MTA monographs No. 129 (1970) “Arsenic, Mercury, Antimony and Gold in Turkey” , No. 133 (1972) “Lead, Silver and Zinc Deposits of Turkey” and No. 145 (1971) “Türkiye Demir Envanteri⁸.” The accuracy of the information contained in de Jesus' catalog of ores in Anatolia needs to be examined, as it is essential to recognize that ores are often polymetallic, meaning that different metals can be extracted from the same deposit. To obtain copper ore, for instance, chalcopyrite is commonly mined and can often be found alongside lead and zinc ores (de Jesus, 1978: 52). This is significant for this thesis, as gold and silver mines are found to contain lead, zinc, and mercury, making it difficult to separate them from one another. In contrast, Wagner and Öztunalı's (2000) survey of prehistoric copper mining in Turkey between 1983-1986 provides valuable information, as 91 out of 142 geologic sites exhibited copper mineralization, with 36 showing evidence of prehistoric mining (Wagner & Öztunalı, 2000: 31). The identified copper mining sites in northwestern Anatolia were numbered only 8: Balya (Wagner & Öztunalı, 2000: 35), Doğancılar (Wagner & Öztunalı, 2000: 36), Yuvalar (Wagner & Öztunalı 2000: 37), Kozcağız (Wagner & Öztunalı, 2000: 37), Keleş (Wagner & Öztunalı, 2000: 37), Gümüşköy (Wagner & Öztunalı, 2000: 38), Tahtaköprü (Wagner & Öztunalı, 2000: 39), Serçeörenköy (Wagner & Öztunalı, 2000: 31).

⁸ Iron Deposits of Türkiye.

3.3.1 Copper

Since copper is the oldest metal exploited for utilitarian purposes, it is significant that Anatolia is very rich in copper. This association allows the mining and smelting of all the metals from the same ore deposit. Despite the wide distribution of copper ore, mining is limited to specific regions in Turkey. Although the Konya Plain (within the vicinity of western Anatolia) and Ergani Mines were considered to be such rich sources that assured copper for all of Anatolia, provenance analysis has shown that this is incorrect (Yener 1983: 2). The presence of small-scale copper ores in western Anatolia lend credence to the assertion for the local usages of this metal. In other words, while this region has its own copper resources, it is also adjacent to one of the main copper sources exploited in Anatolia.

3.3.2 Tin

The case of tin is a controversial topic for Anatolian metallurgy. Locating tin extraction or smelting archaeologically is very hard. Reworking of alluvial gravel deposits over subsequent periods eliminates the traces of any mining and smelting sites. Moreover, smelting of tin produced very little slag (Tylecote, Photos & Earl: 1989).

Although tin was used for various purposes, including the production of bronze by alloying it with copper, Anatolia was only recently considered a possible source for pre-and early historic tin mining. Kestel appears as an ancient mine supplying an abundant tin resource as a previously undiscovered mine. Although it is possible that the mine was not in operation during the Bronze Age, Yener insists on the possibility

in order to explain the provenance of the “elusive tin of antiquity” (Yener, Özbal, Kaptan, Pehlidotvan, & Goodway, 1989: 203). On the other hand, Pernicka *et al.* do not see any possible knowledge for that (Pernicka, Eibner, Öztunalı & Wagner, 2003: 170). Likewise, the area of Hisarcık (Kültepe) consists of numerous irregular mines associated with tin and arsenic-bearing iron ores and small settlements (Yener *et al.*, 2015). Thus, for the time being, only ethnographic, traditional, and experimental evidence can be used to verify the presence of prehistoric metallurgical techniques. However, simple methods can retrieve intricate tin deposits. Earl and Özbal (1996) tested Anatolia's Kestel tin mineralization by a straightforward method, for instance. They demonstrated a technique for obtaining a heavy mineral concentrate through the use of a paddle, commonly referred to as "vanning." Nonetheless, further analysis is required to determine whether the mines were utilized in prehistoric times or not (Earl & Özbal, 1996).

3.3.3 Lead and Silver

There are also substantial lead and silver resources in western Anatolia. The two elements are closely related to one another. Galena (PbS), a lead sulfide mineral, is readily smelted in a campfire using charcoal or dry wood, and lead can be extracted at temperatures below 800 degrees Celsius. (Gale & Stos-Gale, 1981b: 181). Given the rarity of native lead and the fact that small-scale lead smelting had already started in the seventh century BC, the discovery of lead (in the form of galena) smelting was probably an accident (Gale & Stos-Gale, 1981b: 181). Native silver is too rare to have been a significant supply of silver for ancient communities, even though it is not as rare as the native lead. Galena and other complex minerals containing lead and antimony contain silver, in any case (Gale & Stos-Gale, 1981b: 181). As it will be

explained below, they were subject to an extrication method named cupellation, a two-step procedure with oxidation and reduction being executed one after the other.

Silver was found in towns around Çanakkale-İzmir; namely Balya, Sofular, Gümüldür, Sart Mud Baths, Kemal Paşa, Kurudere (Waldbaum, 1983: 5); and there were lead deposits in Salihli, Alaşehir and Lübyayayla (Waldbaum, 1983: 5). The mineralization mainly consists of galena which is a lead sulphide. Kızılca in Dinar is important for its silver-bearing deposits as reported in the MTA (1972: 100). The monograph includes also earlier operations as attested in in Balcılar and Çamyurt (Çanakkale). Balya, for instance, is known to have yielded 400,000 tons of lead, nearly 3 tons of gold, and 1,000 tons of silver when French mining activities were conducted in the late 1800s (MTA, 1972: 83).

3.3.4 Zinc

Sphalerite (Zn-Fe), calamine (ZnCO_3) or smithsonite, blende (ZnS), carbonate (ZnCO), and hemimorphite (Hmp) are the primary forms of zinc that are typically found in nature. These ores are typically found alongside copper and lead ores; in fact, sulphidic copper ores virtually always contain zinc (Craddock, 1978: 2). Zinc is another element abundant in Anatolia. In the case of western Anatolia, notably, the deposits of Mysia contain it alongside lead and silver. However, its potential for the ancients and the archaeological evidence is highly conspicuous and needs further research. One of the main difficulties is to determine the possible zinc deposits used in antiquity. Only a few zinc deposits have evidence of ancient mining activities. The practical explanation is that most early metallurgical sites may be identified by the mounds of sturdy slag left over from the relevant smelting operation (Radivojević *et*

al., 2010: 2776). Yet, very little slag is produced during the thermal processing of zinc ores, leaving little visible surface trace. This might be the practical explanation for the lack of slags that made it difficult to determine the ancient zinc processing deposits. The smithsonite (alternatively known as zinc spar) ores, on the other hand, would only need a straightforward calcining procedure, which is likely where the brass was being manufactured. For instance, evidence of Roman activity found in Stolberg, close to Aachen in Germany implied the same (Craddock & Eckstein, 2003: 222). Large deposits of smithsonite would have been an obvious source, and there are at least three located in Anatolia (MTA, 1972). The complex argentiferous lead-zinc-iron-arsenic sulphides were the ores in the ancient silver mines at Balya Maden, close to ancient Andeira, in northwest Anatolia (Leaf, 1914: 23).

3.3.5 Gold

Gold mining in western Anatolia dates back to as early as 3000 BC, starting approximately with the extraction of alluvial gold from Astrya (Bayburtoğlu & Yıldırım, 2010: 43). Most of the gold produced during antiquity came from alluvial gold, which was their main source of this metal. In later chapters, the mythological tradition surrounding the Paktolos River in Sardeis, which was renowned for its electrum deposits, will be evaluated. At this stage, it is sufficient to state that the veins of metamorphic rocks are the true source of the gold supply. As these rocks deteriorated, they released the gold, which was then transported and concentrated in a nearby basin (Brooks, Öztürk & Cansu, 2017: 45).

Recent explorations near Sardeis have confirmed the presence of gold and indications of ancient mining activity. According to a report by M. Collignon,

Smyrna engineers Catalanos and Axiotakis discovered a quartz vein with traces of a nearby water conduit, which was interpreted as part of a mineral washing installation (Waldbaum, 1983: 4). The precise installation location and date have yet to be determined. The director of the Princeton team, H.C. Butler, claimed to have collected gold shards in pits excavated in the Paktolos bed (Shear, 1924: 188), but no scientific evaluation of these findings was provided (Waldbaum, 1983: 4). In the archaeological context, the gold deposits in the west are both more widely known and more numerous than previously thought (de Jesus, 1978: 99). There are at least 13 sources, regardless of whether they were employed in antiquity.

3.3.6 Iron

The first instances of iron use in Anatolia date back to the third millennium BC, despite the fact that iron gives its name to the post-Bronze Age period in the archaeological context. Iron extraction technology was devised in eastern Anatolia as early as the beginning of the second millennium BC. The earliest evidence of iron smelting in the form of slags dates to Stratum IIIc at Kaman Kalehöyük (Akanuma, 2007: 125-7).

Meteorites and rare terrestrial deposits of native (telluric) metal also contain metallic iron. An important issue about early Anatolian ironwork is distinguishing whether the finding is cast from meteoric or smelted iron (Erb-Satullo, 2019: 563). Hittite texts include a certain word, “sky-iron,” (Rickard, 1941: 55) which was interpreted as referring to iron from meteorites. There are others, on the other hand, viewing it as referring to the color characteristics of a specific form of smelted iron (Yalçın, 1999: 183-184).

Although the presence of Iron during the Bronze Age is not well-supported, this may be attributed to its susceptibility to its corrosion over time and insufficient analyses so far. Prior to the Bronze Age, a cartographic representation of locations for Iron production would include Hattuša (12th century), Gordion (11th century), Sardeis (9th century), Klazomenai and Phokaia (11th century) (Mokrišová & Verčík, 2022: 153; Yalçın & Özyiğit, 2013; Yalçın & Cevizoğlu, 2012), thereby signifying a pattern. However, it is imperative to note that further progression is not present in the archaeological record for the time being. Despite the existence of Iron production on an industrial scale, as opposed to prior beliefs, its prevalence still remained limited. In the later stages of this thesis, I will argue that this is due to cultural factors rather than a lack of techniques.

CHAPTER 4

ALLOYING TRADITIONS

4.1 A Brief History of Metallurgy in Anatolia

Anatolia has an extensive tradition of metalwork, dating back to the 9th millennium BC (Yener, 1983: 1). The oldest known working methods were cold hammering and annealing, which makes copper (especially in the oxidized form of Malachite) to be utilized as the earliest metal (Yalçın, 2016: 5). However, the usage of this procedure does not necessarily conform with the actual meaning of “metallurgy”, with generally implies extractive techniques like smelting. In fact, repeatedly striking an object to alter its form is a common technique in *both* the production of flintstone tools and early metalworking (Zimmermann, 2021: 266). The knowledge that the use of heat to more easily shape raw materials is also suitable for lithic artifacts suggests that prehistoric men might not have recognized metal as being an entity different from stone after all (Zimmermann, 2021: 266). For the first instances of extractive metalwork in Anatolia, the axes and tools from the 16th layer of Mersin-Yumuktepe (around 5000 BC) must be brought to the fore since they were definitely cast through a smelting process (Yalçın, 2000: 19; Zimmermann, 2021: 266). However, any substantial development in metallurgy in Anatolia does not exist for the following 1500 years. That is to say; metallurgy did not progress in a straight line from the 9th

millennium: only after about 3500 BC there appears to be (again) a rise of extractive metalwork. It should not come as a surprise that, after the resurgence of copper-casting, gold, and silver mining technology also started to advance in the western part of Anatolia during the 3rd millennium BC (Yener, 1983: 1; Bayburtoğlu & Yıldırım, 2010: 43) - a period one might call as the second phase of (extractive) metallurgy in Anatolia⁹.

4.2 Copper & Tin

Copper can be alloyed naturally and artificially with various other metals. When exposed to oxygen, it readily oxidizes into green-colored oxidation products. Copper was smelted either directly in simple depressions in the ground in a charcoal bed or alternatively in small crucibles filled with glowing charcoal in simple depressions or simple coarse stone crucibles (Hauptmann, 2020: 305). It could also easily be hammered and annealed. In traditional copper casting, contaminants were removed from copper ore by heating it. The resultant product would then be charged into the smelting furnaces to produce crude copper. This would again be heated with charcoal in the open air. The metal would then be repeatedly remelted until its quality improved (Haedeke, 1970: 19).

Copper and tin were combined in a smelting process to produce bronze (Haedeke, 1970: 27). To process it, metal ores in a furnace were heated to a temperature where the metal would separate from the rock it was embedded and liquify. In order to

⁹ On a terminological note, the word “bronze” refers exclusively to the alloy of copper and tin. Element names other than these two elements that affect arsenical copper etc., will be used by prefixing them, and thus the usage of “tin bronze” will be avoided.

create different shapes and objects, the molten metal could then be poured into molds (Haedeke, 1970: 35). Another technique referred to by Coghlan (1975: 64) as "casting-on" was sometimes employed during the Bronze Age. If a piece of a bronze object was broken, the casting-on procedure could be used to repair the damage, consequently leading to recycling.

4.3 Silver & Lead

The metallurgy of silver production is related to the metallurgy of lead. Besides that, it is also related to gold. Silver was extracted in antiquity from gold-silver deposits as they occurred, the milestone for the extraction of silver from gold is Sardeis (Hauptmann, 2020: 337).

Cupellation is a metallurgical process conducted at high temperatures with the objective of purifying noble metals present within a larger metal matrix, typically consisting predominantly of lead. Melting the metal in an oxidizing atmosphere oxidizes lead into litharge. This chemical oxidizes base metals and interacts with metal oxides to form fusible compounds. Thus, noble metals form a button from the molten mixture because they are inert to oxygen and lead oxide (Torres & Thomas, 2008: 60). The most straightforward cupellation method was to set silver-bearing lead in a small, closely packed ground depression -a so-called cupel. After they were inserted into a furnace floor depression with a slightly domed roof; clay, limestone, and ash-lined walled flat masonry hearths were employed. Its fuel was wood or charcoal. When top heat melted lead, removing newly produced litharges from the liquid surface would complete the process. Iron sticks and litharge cones are found in

old village workshops as the solid archaeological evidence of the last step (Hauptmann, 2020: 341).

Nevertheless, cupellation often leaves some lead behind in the silver. There must have been an increase in interest in lead smelting following the realization that silver could be extracted from cupelling silver-rich lead. Lead is naturally malleable and flexible, tarnishes quickly, and, according to earlier scholarship, was initially not very useful (Gale & Stos-Gale, 1981b: 181). The earliest lead smelting was the relatively easy low-temperature smelting of pure galena ore (Gale & Stos-Gale, 1981b: 181).

4.4 Zinc

Zinc is abundant in copper ores in the Eastern Mediterranean. Early in the first millennium BC, copper was alloyed with antimony or perhaps silver (Craddock, 1978: 4). However, the procedure for its usage is a subject of debate. Previous scholarly works had posited that the element zinc remained undiscovered until the seventeenth century AD, and that its pure form was not utilized in Europe (Haedeke, 1970: 28). Controversially enough, the earliest artifacts containing unusually high amounts of zinc come from Early Bronze Age Cyprus (Craddock, 1978: 2). This case is considered accidental due to the lack of metallurgical means and the polymetallic composition of the deposit (Craddock, 1978: 3). The main reason behind this statement is that the modern procedure for distilling zinc is different and would require a system the ancients are not known to have used. This is because of zinc's volatility, which causes it to be lost rather than absorbed during the smelting of the copper. It was asserted that if zinc was tried to be acquired from copper ores, the

majority of the zinc would be lost during the roasting process required if a sulphide ore were to be employed in order to transform the sulphides into oxides (Craddock, 1978: 2). Thus, the artifacts including significant residues of zinc that are older than the 1st century AD are approached very cautiously (Craddock, 1978: 7).

However, this perception needs to be challenged. As to be clarified in the final chapter, the supposition that the ancient civilizations lacked the technological capability to alloy zinc is no longer tenable. I propose that it is closely related to ancient experimental enterprises. Craddock asserted that the instability following the collapse of the Mycenaean thalassocracy had made tin scarce, so an alternative had to be found (Craddock, 1978: 4). Zinc may indicate a subsequent, ultimately more successful, attempt to replace tin. However, the motives behind the replacement may be different from what Craddock thought. While early theories regarding the "shortage" of bronze during the end of the Bronze Age were largely speculative, Mokrišová and Verčík (2022: 145) propose a different perspective. They suggest that commercial activity involving bronze persisted during the late 13th and throughout the 12th centuries BC, albeit in a more decentralized manner. Therefore, in the absence of a shortage of bronze, the development of brass may potentially be attributed to experimentation for the sake of experimentation (but see also below).

4.5 Brass

The production of brass is made through the process of alloying calamine and copper, a relatively uncomplicated procedure (similar to the making of bronze). Obtaining these metals from oxide ores would require a technique called

cementation. During cementation processes, a chemical reaction occurs between a solid metal and a gaseous phase, resulting in chemical transformations (Hauptmann, 2020: 300). Chapter 6 will provide a speculative analysis of the implications of the potential consequences of the production of brass during ancient times. To comprehend the basis of the modern bias and brass' "second" invention, certain Medieval documents shall be presented here.

Among those who dwelt on the issue of metals during the Early Modern Age was Georgius Agricola with his manuscript *De Natura Fossilium*. Several recipes dating back to the 16th and 17th centuries exist for the production of brass, which shares a common procedure. In sum, to manufacture brass, a considerable amount of space is required, and this area must be covered with a roof to allow for the rising vapors to escape through the top. Additionally, for safety purposes, the support beams for the roof tiles to be made of iron instead of wood. The furnaces are positioned in the ground so that the wind can propel the flames of the fire through the orifices located beneath the furnace, stoking the coals and causing them to burn. The heated metal is then broken into pieces while still warm, yet in a way that allows the pieces to stay close to one another. The metal is poured from the crucibles onto substantial stones that have been prepared for this purpose in order to form pots, containers, or wire from it (Haedeke, 1970: 30). With the standard furnaces in antiquity, however, zinc would rise along the shaft in the state of vapor and swiftly oxidize back to a whitish zinc oxide, not pooling in the lower portion of the furnace as a liquid metal (Hauptmann, 2020: 375).

4.6 Gold

Gold was present both in its pure (solid) form and in the form of electrum in Lydian geography. Electrum, a natural alloy of gold and silver, emerged from the Paktolos River, which had Mount Tmolos as its source. There were various methods to produce it.

Before processing, roasting could be applied to loosen the grain structure of the ore and reduce its moisture content (Hauptmann, 2020: 323). In poor gold-bearing ores, after a possible preliminary roasting, the gold-containing ores would be combined with lead, lead sulphide, or lead oxide for smelting. The ensuing smelting procedure is lead-dependent (Hauptmann, 2020: 323). As it is always found with silver, cupellation was also utilized with gold.

For the Lydian case, amalgamation, cementation, and gilding bear vital importance. The ability of silver to form chlorides, sulphides, and sulphates, in addition to nitrates, is the basis for this refining process to separate gold and silver. The separation of gold and silver by sodium chloride (NaCl) is among the most well-known cementation procedures (Hauptmann, 2020: 327). Archaeological excavations in Sardeis have revealed the existence of a workshop situated along the banks of Paktolos at PN sector, which applied at least two techniques - cupellation and cementation. Cementation was employed to separate the gold and silver, and the workshop contained several furnaces, lead oxide, lead slag, and fragments of thin gold foil (Waldbaum, 1983: 7).

Gold (or silver) must be prepared as finely as possible and be in a metallic state for amalgamation. After the initial extraction of gold by panning, gold-bearing sands, and sludge are intensively mixed with mercury. Physically, the thin, liquid metal dissolves the gold particles (Hauptmann, 2020: 326). Today, amalgamation is frequently utilized in localized alluvial gold mines all over the world. It is a crude procedure that starts with washing the gold-bearing sediment to obtain a gold-bearing pan concentrate, followed by adding mercury to amalgamate the gold, removing the amalgam to release the gold and mercury, and burning the amalgam to release the mercury. From local cinnabar occurrences, mercury was retorted and the process of amalgamation was thus carried out by the Lydians as well (Brooks *et al.*, 2017: 56). In addition to amalgamation, other methods involving the use of carpets, sheepskins, and other animal skins for extracting gold from alluvial deposits were also utilized, and are still employed in small-scale gold mining operations today in Peru and Venezuela during the initial stages of gold concentration (Brooks *et al.*, 2017: 44).

4.7 Iron

Iron ores are abundant and available in vast quantities across the world. Producing iron was more challenging than the previously known metals (Hauptmann, 2020: 364). It was produced through a method known as bloomery. In a shaft furnace, roasted ore would be charged with iron ore and charcoal. Its temperature range for the reduction is between 800 and 1200 °C. Yet, metallic iron in the bloomery process reaches the liquid state only to a limited extent and is obtained as a porous bloom in the solid form. The billet was then subjected to repetitive hammering, folding, and

kneading while hot, compacting the porous iron and removing the inclusions in order to create a useful piece of iron (Hauptmann, 2020: 364).

The data for iron smelting and smithing from the Aegean before the 8th century BC is scarce. Yet, this portrait creates a bias not to investigate further the subject (just as described in Chapter 2.4.). In Chapter 2, the case of corrosion is described. Due to its fast oxidation rate, iron is usually found in rusty fragments. Corrosion can destroy an item completely. In settlement sites, which were intensely occupied for millennia before and after deposition, taphonomic processes or earlier human acts hastened the process (Mokrišová & Verčík, 2022: 146).

Being either meteoric or refined, the existence of an iron industry in the Kingdom of Hittite is subject to debate. Iron was used in Late Bronze Age Hittite peripheries Sardeis and Gordion in the eleventh and ninth centuries BC, respectively. The metallurgical debris showed refining and smithing, likely the oldest iron works in the Aegean and western Anatolia. Mokrišová and Verčík (2022: 153) even assert that this metalworking tradition had continued since the transitional era of the first half to the second third of the eleventh century BC, therefore, it is plausible that early in the first millennium BC, local experimentation with hardening was conducted at Sardeis (Mokrišová & Verčík, 2022: 154).

4.8 The Furnaces

Furnace and waste residues are necessary for reconstructing the history of metal production. The waste materials produced through metallurgical processes provide

reliable evidence of the techniques and procedures utilized at the production site. There are three main types of evidence left behind by metallurgical processes: raw metal lumps and spills, semi-finished products, and objects for repair or recycling; associated products like discarded ore, slag, matte, and speiss; and remnants of tools and installations like crucibles, hammers, tongs, or furnaces (Rehren & Pernicka, 2008: 235). Slags are the most informative, abundant, and well-preserved type of waste material, but their contents can only be revealed through scientific analysis and expert interpretation (Rehren & Pernicka, 2008: 235). Previously it was assumed that the majority of the metallurgical activity most likely occurred at or close to the deposits or the rivers, so the remains of the most ancient “furnaces” were considered scarce (de Jesus, 1978: 68). However, this picture is changing through the recent finds that may imply the existence of prehistoric furnaces in Anatolia.

Some of the findings at settlements like the Neolithic site of Çatal Hüyük are extremely likely to represent the debris of proper extractive metallurgy, supporting the theory that smelting was done at communities away from the mines (Craddock, 2000: 155). The Anatolian examples, located quite a distance from the nearest ore source, are therefore accurate representations of ore transportation from mine to town (Craddock, 2000: 153). As Yakar and Schmidt (2004: 80) present, findings of a furnace from Norşuntepe date at least Late Chalcolithic/Early Neolithic. Malatya-Deirmentepe, Malatya-Arslantepe, Kültepe/Kaneş, and Boğazköy-Ḫattuša also contain early metalworking workshops in Anatolia (Cevizoğlu & Yalçın, 2012: 75). According to Cevizoğlu and Yalçın (2012: 75), the locations designated for the workshops even have a certain pattern: they may be on a small wind-exposed hill or terrace, away from the city center where they could find wind or a source of water.

Sardeis and Klazomenai are the best-preserved examples of metal workshops from Iron Age western Anatolia. The available evidence indicates that both were in industrial districts. In Sardeis, for instance, spaces adjacent to other large Roman buildings were also used as workshops (Cahill, 2010: 88) . Although raw materials like slag and the products of metal workshops can be found in many settlements, it is uncommon to find a workshop that has been excavated along with its facilities, equipment, and installations (such as anvils and hearths) along with the products (Cevizoğlu & Yalçın, 2012: 76). This is why the workshop at Klazomenai serves as such a fine example. Drainage channels and water supplies are extremely common installations in an industrial neighborhood and may indicate the presence of a work area. A water channel discovered during excavations in the HBT Field Sector at Klazomenai runs northwest to southeast (Cevizoğlu & Yalçın, 2012: 76). It utilized the north wind to its benefit. Multiple fragments of slag and a few pieces of iron tools that were recovered belonged to the workshop. Even steel was produced there, as indicated by the remnants of a refined bloom (Cevizoğlu & Yalçın, 2012: 79-80). Cevizoğlu and Yalçın (2012: 78) correctly assert that the tradition of metalwork in western Anatolia goes earlier than the Iron Age, and they see the finds from Liman Tepe as a good potential to link the tradition even earlier.

CHAPTER 5

METALWORK AND METALWORKERS IN 1ST MILLENNIUM: FOLKLORE AND LITERARY TRADITIONS

5.1 Western Anatolian Folk Beliefs on Metallurgy

This chapter will examine ancient written sources (mainly Platon, Herodotos, Strabon, and Pseudo-Demokritos) to establish what the ancient societies of western Anatolia (Lydia, Mysia, and Phrygia) thought about the origins of metal sources, metallurgy, and metalworkers. When dealing with ancient narratives, it can be tempting to apply modern perspectives and terminology, such as the terms "myth" or "legend." However, these terms carry connotations that may not accurately reflect the views and beliefs of the ancient peoples who originally told these stories. According to the Oxford English Dictionary, a myth is "a traditional story, especially one concerning the early history of a people or explaining some natural or social phenomenon, and typically involving supernatural beings or events" (Oxford Reference, n.d.). While myths may contain elements of the fantastic or supernatural, they were not necessarily viewed as fictional or untrue by the people who told them. Rather, they often served as important cultural touchstones, helping to explain the world around them and their place within it. A legend, on the other hand, is "a traditional story sometimes popularly regarded as historical but not authenticated" (Oxford Reference, n.d.). Unlike myths, legends may be based on real historical

events or figures, but they often contain embellishments or exaggerations that blur the line between fact and fiction. Like myths, however, legends can serve important cultural and social functions, helping to define a community's shared history and values. While both myths and legends have important cultural and historical significance, the terms themselves may not accurately reflect the beliefs and perspectives of the ancient peoples who originally told these stories. The main reason for this assumption is that myth is examined within the frameworks of various disciplines such as anthropology, psychology, sociology, philosophy, and literature, each offering its own theories and perspectives for explaining phenomena discussed in humanities (Segal, 2004: 2). Instead, in order to approach myth for myth's own sake, it may be more appropriate to refer to these narratives as "folklore," a term that acknowledges the cultural and historical context in which these stories were created and transmitted (Baldick, 2008: 471). By using this term, one can better understand and appreciate the significance of these narratives to the people who told them without imposing our own modern interpretations.

I selected the literary sources from ancient authors according to the audience they spoke to. In order for the mere metalsmiths who did not have too much time to contemplate nature, the most plausible way of expressing (or learning) their knowledge must have been the folk tales. A case in point is the role of *Ilias* and *Odysseia* in Ancient Greek society as educational sources (Goldman, 1989: 391). The technical knowledge they included between the lines of the story was able to constitute a "syllabus" for nearly all the crafts in antiquity. The most detailed picture of the work of a metalsmith is the sequence where Hephaistos forges a new shield for Akhilleus (Hom. *Il.* 18. 462-590). The techniques he utilized imply Iron Age

metalwork. Keeping in mind that Homeros (or the tradition called with this name) hailed from western Anatolia, the epics must have functioned similarly in this region as well¹⁰, thus being manuals for ancient smiths. Other literary traditions must also have served as guidelines for crafters like metalworkers. It is sufficient to note that evidence of widespread literacy in the late fifth century (Flory, 1980: 12) suggests a sizable public demand for books. Herodotos' histories, for instance, found an audience of common people (Flory, 1980: 28). However, the common people must not have had a high level of literacy. In other words, even if they couldn't (or didn't) write, the craftsmen (even metalworkers) could presumably read to some level. So, the best way to describe them is as semi-literate. The more sophisticated works like Aristoteles or Pseudo-Demokritos, on the other hand, I present to display the knowledge stemming from (or supporting) actual metalworking in theoretical "science."

The research now evaluates folk narratives that include ritual at the stage of extracting metals due to the fact that metal transformations always include ritual expression. Since the identities of metalwork and metalworkers shall be examined, how the aforementioned geography and mineral resources were perceived by the ancients is a key for understanding them becoming a niche in the construction of material culture since they provide us with the limits related to mineral wealth the settlements had. Thus, investigating those resources will also reveal their primary users' role in society by displaying the capabilities they could have.

¹⁰ Both *Ilias* and *Odysseia* stayed as oral traditions until the order of Peisistratos (a tyrant of Athens) to put them into writing (around 550 BC) (Tekin, 2008: 74). Nevertheless, they were being orally transmitted until then.

Since the formation of minerals is established in Chapter 3, it is important to understand to what extent the ancients perceived this formation and how well they knew the structure of its sources before moving on to the function of the metal in the written sources. At this point, it will be beneficial to go through seismology, especially in the context of Anatolia, since it is an actively moving region. This will display not only the perception of earthquakes by the ancients but also the awareness of geological structures and mineralization.

Many of the metal ores have been formed as a result of mineralization, which has often been influenced by seismic and volcanic activity. Certain local myths suggest that the societies who circulated these myths were aware of the origins of the available metal ores. As was stated above (Chapter 3), the extinct Kula volcanoes in western Anatolia (sources of obsidian), illustrate this. The ancient designation of this area - *Katakekaumene* in Ancient Greek, which translates to "the Burnt Land," (A Greek-English Lexicon, 1999) - suggests an awareness of the volcanic nature of the Kula region. In myth, it was asserted that this is where Zeus' ultimate fight with Typhon, a devastating dragon-like creature, took place (Strab. 13.4.6). This was how the blackness of the earth and the easy access to obsidian reflected in society. The notable part is the link between the obsidian and ancient volcanic area was related to the origin of the mineral.

Hephaistos, the deity of blacksmiths, was known as Vulcanus in ancient Rome. Given that obsidian, a valuable mineral in antiquity due to its ease of working is also sourced from volcanic regions, it is very plausible that an ancient deity related to metallurgy would be named after one of the first minerals to be utilized by mankind.

Undoubtedly, the scope of awareness extends beyond just volcanoes. *Kýklōpes* [Cyclopes] (A Greek-English Lexicon: 1999), the Olympian gods' blacksmiths, serve two purposes in understanding this connection. First, they were servants of the god Hephaistos, as their profession should imply. Second, they were also Poseidon's offspring, the god of the *earthquakes*. This also explains why a cult dedicated to Poseidon exists in an inland region away from the sea like Kelainai within the borders of modern-day Afyonkarahisar¹¹ (Strab. 12.8.18). In light of the fact that the *Κύκλωπες* are descendants of Poseidon *Ennosígaios* [the Earth-Shaker] (Lexicon n.d.), it can be argued that ancient records of earth tremors (seismic activity) attest to the discovery of ores. Moreover, earthquakes were perceived by the Ancient Greeks as Poseidon shaking the watery layer they believed existed beneath the ground before Hades or the Underworld (Güney, 2015: 294). Such a view of geology is interestingly reminiscent of what is now called the lithosphere by geologists and its unstable nature.

Although there are competent studies on the perception of ancient seismology (Harry 2002), research on Anatolian settlements has not been able to take its share from it. Elsewhere, Tokmak and Toprak (2012: 57) claimed that the ancients were “far behind the recognition of a fault line.” However, the fact that they do not use terms from contemporary science should not imply that the ancients were unaware of plate tectonics. Tokmak and Toprak’s argument is based solely on the lack of geographical distance to a physical structure called “fault” in the modern concept. Yet, the continuation of urban settlements in earthquake-hazardous areas for millennia should

¹¹ Through numismatic evidence, Güney has argued that the presence of Poseidon on coins was initially connected to the historically attested earthquakes in western Anatolia during classical antiquity (Güney, 2015).

be enough to overturn this hypothesis. In Hierapolis, they did not only understand that there was some kind of a connection between the ground and Hades, but also built a Ploutonion on what we nowadays call as a fault line (Hancock & Altunel, 1997: 25)! In Greek myths, there were several entrances to Hades. I assume that the locations for the gates were not given randomly and Hierapolis displays a fine example for the designation. In the end, one sees that the ancients knew they lived on a very unstable lithosphere, even though they did not mark the fault line as concrete as the modern fault maps. It is very likely that the Ancient Greeks derived their understanding of the instability of the lithosphere, or Earth's outermost layer, from their knowledge of groundwater sources¹².

Another work in the field is Cevizoğlu's article "Iron Metallurgy in Ionia" (2015), which constitutes a significant milestone in demonstrating the presence of metalwork in ancient Anatolia as reflected in folklore and a prologue for it. However, there are some issues with the terminology used in the article, particularly in the naming of "*daimonoi*" as "Elves," (Cevizoğlu, 2015: 248) which are not from ancient Aegean culture and have a completely different epistemology. The use of "wizard" (Cevizoğlu, 2015: 246) for magical smiths is also problematic and could be better replaced with "sorcerer" or "conjurer." Additionally, while the article attempts to connect the mythological names and geographical regions, it does not delve deeply into the folklore and leaves some gaps in understanding. Nevertheless, Cevizoğlu's work contributes to the study of metalwork in the culture of Iron Age Anatolia and provides a foundation for further research in this area. As he also acknowledges the

¹² Since the ancients did not hide this much, the aforementioned authors accepted so far, but Tokmak in his thesis gave an explanation that cuts off the possibilities for rational arguments between myth and seismology, suggesting the relationship was limited to "Poseidon's bad mood" (Tokmak, 2012: 23).

scarcity of knowledge on iron metallurgy in Iron Age western Anatolia (Cevizoğlu, 2015: 246), it is challenging to establish such connections with the currently available data. Nevertheless, metalwork analyses conducted with the knowledge that Iron Age Anatolia has a significant amount of written sources referring to its history should gradually extend this field over time.

Considering that the primary characteristics of the gods vary from region to region, I propose that Poseidon's association with earthquakes is the prominent one in Anatolia. A significant indicator for this sense is the archaeological examination of Troia. Although the epics of Homeros should be considered fictional, excavations showed that the layer which is associated with this fictional story was destroyed by earthquakes (Nur & Cline, 2000: 56). In *Ilias*, gods are divided between the two sides of the war. Considering that their sides are associated to their characteristics, the nature of Poseidon's involvement gains a deeper meaning. *Akhaioi*¹³ he supported entered the city with a wooden gift in the shape of Poseidon's divine animal: a horse. That is to say, the whole narrative may be an analogy of a very destructive earthquake that razed Troia to the ground.

Ultimately, it is reasonable to assume that the ancients observed the movement of tectonic plates and water and recognized their interrelatedness. Among the Presocratics, Demokritos, an inhabitant of western Anatolia, is the first known researcher to develop a scientific theory regarding the relationship between earthquakes and water (Aristot. *Meteor.* 2.365b). In the end, traditions regarding Hephaistos, *daimonoi* and *kyklōpes* working under mountains and using furnaces for

¹³ The invaders from West as Homeros called them (Tekin, 2008: 46).

their volcanoes is able to show the link between mineralogy and seismology. The main indicator for this conclusion is all the aforementioned beings are not just distinct analogies of metalwork but also connected to each other.

As is already demonstrated, the scope of metallurgical folklore is not limited to Hephaistos. Actually, the portrayal of the ancient smith as a disregarded cripple man must be another product of the Athens-based reading of Ancient Greek culture. Although the Aegean world was much broader and diverse, the obstacle created by a strong loyalty to written sources limited the historiography of Ancient Greece with the narratives given by Athens. Contrary to the disregard for crafts in Athens (Lindsay, 1970: 28), western Anatolia can display another picture. *Daimonoi* are great mediators between the divinities and their association with metals. Through them, The Great Mother who dwells on the mountain slopes (Blakely, 2006: 83-84) could have eventually be identified as the giver of the ores. That is to say, a region with a much older history of metallurgy and a higher regard for it as a craft seems a more salient model for the picture of metallurgy in ancient societies.

Anatolia has a long-standing tradition of mother goddesses who can be equated with the Greek Rhea. However, the concept of a mother goddess might be the most misinterpreted case in archaeology. Unfortunately, the earlier scholarship was eager to associate every sexualized item with fertility and every goddess with any “fertilized” item to the much-debated “fertility goddesses.” (Stuckey, 2005: 34) Yet, a deeper investigation into the goddesses associated with the earth can give more realistic accounts of their function. Rhea, for instance, seems associated with mountains rather than the soil of the earth. *Daimonoi*, who helped the transmission of

the metallurgical knowledge, are nearly always the servants of the Titaness Rhea. It is also significant that her cult can be found in the places where an established tradition of metalwork was present and metallurgical *daimonoi* came from -Crete (Marinatos, 2007: 353), Mysia (Güven & Şahin, 2019: 146), Phrygia (Bøgh, 2007: 305)¹⁴.

Two *daimonoi* hold significant importance for western Anatolia: *Daktyloi* and *Kabeiroi*. *Daktyloi* are believed to have originated from Rhea's imprint on the ground, created as she was in the process of birthing Zeus (Nonn. D. 14.23). The birthplace of these deities was believed to have been either in Phrygia or on the island of Crete, specifically on Mount Ida in both cases (Strab. 10.3.20). *Daktyloi*'s name was derived from the mountain's toes, where mining activities took place, which served as a metaphor for Rhea's fingers (Blakely, 2006: 14). They are credited with the invention of iron (Blakely 2006: 14). They are said to have learned their craft from the Mother Goddess. *Kabeiroi* are from Northern Aegean, possibly from Phrygia, and are the sons of Hephaistos. They were related to defensive structures and both the Milesian and Pergamene mysteries. Pausanias transmits that *Kabeiroi* were the most ancient deities of Pergamon (Paus 1.4).

Daimonoi were often read as the sexualization of metallurgical procedures (Blakely 2006: 79). Particularly female sexuality is closely related to metal production in folklore. In a comparative-ethnological study, Blakely (2006: 99) explained that the procedure of iron smelting itself is reminiscent of sexual violence in recent African

¹⁴ A similar case can be seen with Persephone as well, who must be taken as way more than just a spring goddess. It is no coincidence that Hades was connected to agricultural fertility (through her) as well as *metallic* wealth since those minerals are found underground.

tribes. She defined the whole procedure and workshop as “a technologically constructed woman” made for male-oriented work. The procedure includes ritualistic songs and dances, which strikingly remind of the Kabeiric rituals to please the feminine divine in ancient Greek folk tales¹⁵. Although the essence of the tradition implies a struggle between the male and female consciousness, this is something different than Freudian acceptance. It does not imply a “phallic conquest” of the female, but a consonance. Even if ore deposits are thought of as representing the female body (or womb), her role is absolutely not passive. In various myths, the goddesses associated with mountains are escorted (*not* dominated) by their male consorts. For her to bestow the knowledge, agreement is necessary. Blakely (2006: 97) asserts that her function as a mother has more to do with regional ownership than sexual reproduction. Although we do not know much about the Milesian and Pergamene mysteries, Eleusis presents a great analogy: The *Kabeiroi* mysteries appeared to be a technological analogy there. Eleusis was the place where Demeter bestowed the secrets of metals to mankind after her search for Persephone was complete¹⁶ (Blakely, 2006: 81). The most significant indicator here is the divine feminine's function as the instructor. Even in later historical eras, women were associated with expertise in metallurgy. According to a Hermetic tradition transmitted by Tertullianus, the origin of metallurgy and dyeing is angels who were cast out from heaven and descended on women. (Tert. *de cultu*. 2b).

In conclusion, the mythological image of Hephaistos is primarily the result of Ancient Athens' disregard for craftsmanship. Along with Hephaistos; Poseidon,

¹⁵ *Exempli gratia*, the dance of *Argonautai*: Apollon. 1.1130

¹⁶ This should also imply that folklore around agriculture and metallurgy was connected as they both were important for the primitive men to become civilized. This can be a reason of why “fertility goddesses” have been misread this whole time.

Rhea, the *daimonoi Kabeiroi*, and *Daktyloi* were among the chief deities worshipped by Iron Age metallurgists in Anatolia. The most convincing evidence is the existence of metal-related mystery cults in Miletos and Pergamon, dedicated to the explicitly mentioned deities (see Chapter 5). Moreover, as was stated above, the folk tales could have potentially worked as manuals for metalsmiths apprentices. Yet, not only the casting techniques between the lines but also the myths themselves should be taken into consideration for they can display the self-image of the metalworkers. Going back to the 18th book of Ilias (Hom.*Il.*18), where Hephaistos makes a marvelous shield for Akhilleus, the depictions on the shield are interpreted by various scholars even in modern academia. In brief, it is sufficient to state that it beautifully narrates the order of nature (Hubbard, 1992: 35). In order to express such sophisticated narratives on depictions, the smiths must have been acquainted with the knowledge themselves. If they saw Hephaistos' work representative of their craft, they may have charged themselves with the task of petrifying knowledge on cast items they produced.

5.2 Political History of Western Anatolia

In order to comprehend the perspectives of the inhabitants of western Anatolia, it is necessary to consider the political history in conjunction with the metallurgical history as the two are not independent. In the 2nd millennium, all main settlements in western Anatolia produced evidence of extensive use of multiple metal types. Notably, Troia, Beycesultan, Miletos, and Limantepe (Mokrišová & Verčík, 2022: 138) are among the most renowned of those, serving as the key areas of inquiry in this thesis.

The first historical attestation for these sites as a unity was implied by the annals of the Hittite king Hattušili I: Arzawa (Collins, 2007: 37). It suggests that during the reign of Hattušili I in the 17th century BC, western Anatolia was regarded as a unified region by a neighboring political authority. Subsequently, this perception was reinforced by an external power, namely Egypt (Cline, 2001: 242). Deep investigations on its political structure, though, reveal that the sociopolitical structure of western Anatolia consisted of a number of city-states and larger political organizations with various administrative elements. These well-formed regional political units could unify if the need arose (Özbaş, 2021: 77), just as Homeros described his Aegean world¹⁷. While archaeological evidence confirms all the sites being the same culture, they could only be a confederation in necessity. Yet, it is important to keep in mind that the Myceneans are not a perfect counterpart for there is a serious variation in material culture which makes it difficult to talk of a common culture in western Anatolia (Özbaş, 2021: 78). However, this cultural complexity has never been a stranger to the western part of Anatolia: its geological composition creates various natural boundaries between lands with its wall-like mountains and frontierlike rivers around isolated valleys and plains, making them distinct countries of their own. Although a similar case is present in mainland Greece, a linguistic overview is able to express the sharpness of the case in western Anatolia: while the Greek cities in different regions of mainland Greece spoke different dialects of

¹⁷ The Mycenaean city states did not have a political unity though they shared the same culture (Tekin, 2008: 46). However, some Hittite texts referring to them as Ahhiyawa imply that they were able to form coalitions to raid (and lead) the western coasts against the inhabitants of Anatolia (Güterbock, 1983: 134). In his epic, Homeros also describes the political structure of the day as such. While the western invaders were united under an oath, the defenders also supported Troia under a one-time alliance.

Ancient Greek, the Anatolians spoke different *languages*¹⁸ before Ancient Greek became the dominant language here (Encyclopædia Britannica, n.d.).

After the so-called “Dark Ages”, even more tribes migrated to western Anatolia, most of them being Ancient Greek-speaking (Tekin, 2008: 65). Their clan names (which also determined their dialect) reshaped the geography: Aiolis, Ionia, and Karia were the names of the Aegean coastlines from north to south. However, it is often forgotten that Anatolia *already* had its native population and all the invaders or settlers eventually adopted it to some degree. The creation of a shared past between Ancient Greeks and Anatolians was a collective effort that had started already in the Bronze Age. The Hittite historiographic and administrative texts indicate that there was extensive contact between the Hittites and their western neighbors, which would have permitted the transfer of gods, performers of narrative song, and other forms of verbal art that lived on even in the Iron Age. *Exempli gratia*, the association of Typhon with the *Katakekaumene* region of Lydia is considered to be of a Hittite origin (Bachvarova, 2016: 343).

In the Iron Age, a map for western Anatolia would include the following regions from north to south: Mysia, Lydia, and Karia (and Phrygia in the interior) (Yavuz, 2010). The Lydians were an indigenous people who had inhabited this region since the 3rd millennium BC, according to the recent diachronic examinations of human bones (Roosevelt, 2009: 35). Although they spoke a language close to Ancient Greek, the Lydian language is also related to Hittite and other Proto-Anatolian languages, too (Roosevelt, 2009: 37). Regarding the origins of Phrygia, it is more

¹⁸ Willemijn Waal's (2019) article on scripts posits that these scripts can be attributed to a sister language instead of the various branches of Ancient Greek, thereby enhancing their distinctiveness.

challenging to reach a conclusion. According to Herodotos (3.73), they had migrated from Thrace. The archaeological evidence indicates a migration, as demonstrated by the post-destruction strata of Troy VII b. These layers reveal the arrival of a new population, who brought with them a type of coarse pottery that appears to have originated in central Europe (Barnett, 1975: 418). Gordion also exhibits a notable phenomenon whereby hand-made black pottery subsequently vanishes, suggesting that its makers may have been assimilated (Barnett, 1975: 418). It is possible that the Muški and Tabal (Barnett, 1975: 417) were earlier names for the region, as suggested by the annals of Tiglath Pileser I. Therefore, it can be inferred that even if an aristocratic Thracian lineage was in power, a significant sense of community had already been established there. Their proximity to the Hittite heartland necessitates mentioning that this was a well-anchored Anatolian region that contributed culturally to the transmission of certain elements of the Hittite heritage in history. Interestingly, the Mysians were considered kinsmen of the Lydians and Phrygians (Strab. 12.8.3). *Aioleis*¹⁹ settled on the Mysian coast afterward.

In its earliest political history, Lydia can be identified as the Seha River Land associated with Arzawa, but its primary presence begins in the early Iron Age. Its first two pseudo-historical dynasties are the *Herakleidai* and *Maeonidēs*, followed by the *Mermnādes*, the Achaemenids, and ultimately Aleksandros III. After Aleksandros III's death, it changed hands in the wars of *Diodokhoi*, passed to the Kingdom of Pergamon, and ultimately became the first Roman province in Anatolia through the will of Attalos III (Tekin, 2008: 149).

¹⁹ *Aioleis*, or the Aiols, are one of the four primary Ancient Greek clans who settled on the western coasts of Mysia at the end of the second millennium (Tekin, 2008: 52).

The Lydian Kingdom gradually conquered all of these regions. Possession and production of metals in Lydia were likely supervised by royalty and the elite (Roosevelt, 2009: 113). A Milesian request to settle in Abydos for the metal resources there from Gyges of *Mermnâdes* might be an indicator of the royal monopoly over metal deposits. The main goal of Gyges might have been to secure the gold mines near Astyra (Roosevelt, 2009: 113). Those mines were between the cities Atarneus and Pergamon. Although there is no evidence of the Lydians using these mines, the appointment of Kroisos by his father as the governor of Adramytteion might be a hint for that (Roosevelt, 2009: 114). After the Persian invasion, the local people were still able to operate gold mines: thus an indicator of the elite involvement in the process of producing gold even after the state's sovereignty was over (Roosevelt, 2009: 114). The political actions undertaken by the state indicate a clear inclination towards mining regions, which may serve as a significant contributor to the portrayal of metals in folklore and culture, as demonstrated in the first section of this chapter.

The best historical indicator for the continuity of active mining in this region is the taxation of the Achaemenids. After India and Egypt, Persians received the third greatest rate of income from this region (Hdt. 3.90). In addition, it should not be disregarded that, despite the fact that they did not use coins in their heartland (Persia), they supervised the production of coins here (Tekin, 2008: 85).

There are significant (albeit indirect) indications that Aleksandros III personally utilized these mines. Engels (1978: 30) once suggested that after his victory at Granikos, he probably traveled to *Troas* instead of going to Dasklyleion (as most

maps for his campaign suggest, though no ancient author mentions the exact route). Then, he traversed the geography of Lydia and reach Miletos. Before the king embarked on his expedition, the Macedonian treasury was empty. Therefore, he required immediate funds not only to continue the expedition but also to *initiate* it. After Granikos, where he fought his first battle, the fact that he traveled around a geography where mining is so active and profitable suggests that he worked them and used the income. His speech after the Opis mutiny, in which he emphasized how crucial it was for Macedonia that his father Philippos set the mines to steady work, demonstrates his concern for such matters (Arr. *An.* 7.9.3).

I conclude that the craft of mining in western Anatolia had developed into a tradition and persisted through the invention of some secret arts. In Pergamon, the presence of a mystery cult dedicated to *Kabeiroi* in relation to Rhea during the Hellenistic period confirms the continuation of a very ancient craft legacy (see below).

5.3 Folklore and Literary Traditions from Lydia

Western Anatolia is rich in terms of folk tales involving metallic transformations. The most famous one centers on the great Phrygian king Midas. According to Ovidius (*Met.* xi.), when Dionysos granted him a chance to wish for anything, Midas wished that everything he touched would turn to gold. The prayer was fulfilled, but when he realized that even the food he touched had turned into gold, he begged the god to withdraw his favor. As a result, Dionysos instructed him to bathe at the source of Paktolos close to Mount Tmolos. Midas was spared by this treatment, but the sand of the river at that time was rich in gold. This narrative presents an account for the

genesis of the Paktolos River, Lydia's most famous gold reserve, in addition to recounting in crucial detail the riches displayed by the wealthy monarch of a country known for its metalworking.

The utilization of the sheepskin technique and amalgamation holds significant value in Lydia's gold supply and bears a resemblance to a particular folktale. The arrival of this method in the Aegean is tied to the tale of the Golden Fleece. The most ancient and comprehensive versions of the narrative were recounted by Homeros and Apollonios (Okrostsvaridze, 2018: 7), both hailing from the Eastern Aegean region. As such, the fundamental nature of the narrative is Aegean in character, rather than strictly Greek. The application of the technique in question was found to be present in Kolkhis, where the quantity of alluvial gold deposits is comparable to that of western Anatolia. This observation was made following a comprehensive investigation into the origins of the story by Okrostsvaridze (2018). He investigates the opposite side of the story and concludes that *Argonautika* was also historically told there (Okrostsvaridze, 2018: 38). With the archaeological data presented in the next chapter, I propose that the story might have been transmitted to the western world through the Hittites.

It has already been touched upon that due to the seismic activity, earthquakes are widely seen in western Anatolia. An interesting instance of the breaking of the earth in Lydia comes from Platon. The story is essential for the demonstration of my point, so the whole passage is quoted below.

They relate that he [Gyges] was a shepherd in the service of the ruler at that time of Lydia, and that after a great deluge of rain and an earthquake the ground

opened and a chasm appeared in the place where he was pasturing; and they say that he saw and wondered and went down into the chasm; and the story goes that he beheld other marvels there and a hollow bronze horse with little doors, and that he peeped in and saw a corpse within, as it seemed, of more than mortal stature, and that there was nothing else but a gold ring on its hand, which he took off and went forth. (Plat. *Rep.* 2.359e-d)

The ring then grants Gyges invisibility, which he uses to murder the king and replace him with himself (Plat. *Rep.* 2.360b). Even though it is a moral story, it is still noteworthy as it deals with the ground trembling in the aforementioned region as well as the metals that the earthquake revealed. The tomb may be an allusion to tumuli, which are extremely abundant in this region. The salient aspect of this narrative is its deviation from the conventional trope of a treasure hunt, which is a prevalent motif in the Germanic folklore of Northern Europe. Gyges discovers an object that has been both artfully crafted and imbued with talismanic properties. The colossal corpse under discussion could potentially serve as a metaphorical representation of a *daimon*, given that there exist instances in western Anatolia of folk tales that involve the acquisition of sacred objects and mastery of metalworking through the establishment of agreements with such *daimonoi* (see Chapter 5). Furthermore, western Anatolian chemists still believed in these kinds of incantations in historical times. In Pseudo-Demokritos, the author makes reference to a source from which he obtained the knowledge. Specifically, he recounts having conjured his master's spirit in order to acquire the formula for a certain alloying (Martelli, 2013: 83).

The most exemplary instance of the aforementioned agreement between *daimon* and mortal is evidenced in Miletos. As per the traditional narrative, Miletos was besieged and its citizens prayed for divine help. Tottes and Onnes, two brothers who came

from Phrygia, provided that assistance. They vowed to save the city in exchange for its acceptance of their cult, and the city accepted. They had brought their sacred instruments with them, and these instruments instilled dread in the attacking army and freed Miletos (Blakely, 2006: 17).

5.4 Folklore and Literary Traditions from Mysia

In Mysia, which is close to Phrygia, one can find significant tales that might bring a new breath to the issue of transformation. Aeschylus refers to the location of the *Gorgon* and Medusa's lair as Kisthene (Aesch. *PV* . 780). The naming of this particular area is noteworthy in that it solely appears in Strabon's account of a Mysian settlement. The archaeologist can draw parallels between the towns of Mysia and the transformation myths associated with this region's metal resources and metallurgy due to certain things Strabon stated about them.

Gargara is referenced in the Mysia section of Strabon's account as a place of particular interest. Kisthene is located in close proximity to Gargara. During the era of Strabon, the city had gained recognition for its abundance of copper, however, it had already been deserted (Strab. 14.3.7). The desiccation of the deposits in Gargara remains uncertain. Excluding Strabon's historical geography account in classical literature, the name of this locality has been linked to the youngest of the dreadful *Gorgon* sisters, known for their snake-like locks of hair. In folkloric contexts, there exists a recurring association between the chemical element copper and goddesses associated with beauty. This connection is evident across various cultural traditions, ranging from Mesopotamia and the Aegean (Munday, 2016: 5). Medusa was a

woman who was once widely recognized for her beauty. Following the curse, she started to transform people into stone upon making eye contact (Ov. Met. 4.792). Is it possible for the metaphor to resemble that of Midas, albeit in a distinct manner? Gargara, formerly recognized as significant a metal production center, may have undergone infertility akin to that of Medusa. It is undoubtedly questionable whether the memory of this occurrence had existed for long enough to become a legend. However, the Mysia region still possesses another fascinating and “sacred” metallurgical culture that can give reason to investigate transformation myths and offer another perspective for the metaphor of Medusa since copper was not the only metal found there (See Chapter 6).

5.5 Folklore and Literary Traditions from Phrygia

As Blakely cites (2006: 1), the Ancient Greek language featured a term denoting an arrogant person in the second century AD: "*Kelmis in iron*." This is a reference to a folk tale about the Phrygian *Daktyloi*. During their journey, they came across the revered mother goddess of Phrygia, who was located in the innermost part of Mount Ida. Kelmis, one of the brothers, incurred an offense of some sort, resulting in his confinement within a subterranean prison by his siblings as a form of retribution. Subsequent to an earthquake, he underwent a transformation into iron. Thus, each of the three brothers embodies metallurgical concepts, the other two bearing in their names: Akmon, which denotes "anvil," and Damnameneus, denoting "Hammerer," (Blakely, 2006: 1). This narrative holds significant relevance to the thesis as it recalls the occurrence of occasion between the Phrygian Great Goddess and *daimonoi*, resulting in the emergence of the basic metalworking tools, even during the Hellenized Roman era. For us, it is imperative to acknowledge that the creation of a

metallic substance, iron, is intricately associated with the veneration of the divine feminine and a seismic activity.

5.6 Philosophy in Western Anatolia

“When an Epicurean accused Platon of giving up demonstrable truth for falsehood in the guise of poetic myth, Porphyrios replied that myth was natural” (Lindsay, 1970: 141).

I explained the metallurgical history related to the geological potential of western Anatolia and how, since the Bronze Age, both Hittite heritage and local concepts flowed to the west through centers such as Miletos (Niemeier, 133: 2000), forming a collective culture. As the political structures of the Iron Age stabilized, this resulted in the emergence of various philosophical schools/traditions. The followers of this tradition, known as natural philosophers, sought to explain the structure of matter in a manner comparable to that of modern natural scientists. One can best investigate the natural philosophers' tradition, which continued in Ancient Greece with Aristoteles, from his perspective. He is the one who compiled, albeit critically, the works of these philosophers, of whom we have only fragments. While accepting and rejecting them at times, he explains a worldview with the epistemology they established, and displaying it here will demonstrate the understanding of science institutions in Anatolia during the 1st millennium BC.

Aristoteles argued (*Meteor.* 1.339b) that fire, water, earth, and air are the four elements that are comprised of the qualities of hot, cold, dryness, and moisture. The

natural bodies in circular motion are composed of a single element, and four other physical bodies are produced by their primary characteristics. He asserted that fire, air, water, and earth are all capable of transforming into one another and that each element possesses latent potential in the others. It is intended to demonstrate that all other objects have a single common substratum into which they can, in the end, be resolved. Lindsay (1970: 3) summarizes the early Greek philosophy as a unified process in nature, some ultimate substance that comprises everything. These perspectives exhibit a significant influence from Demokritos: the atom represents the concept of a conflict of opposites as the propelling force of the universe and the concept of a definite structure in the ultimate fundamentals of matter (Lindsay, 1970: 3).

According to Presocratic philosophers (Aristot. *Phys.* 187b), the concept of "becoming" originates from immanent entities that are imperceptible to the senses due to their small size. They state that "everything is mixed in everything." The difference in appearance between the substances is due to their combination. Therefore, it may be useful to consider that the ores in western Anatolia were likely used for the production of more than one metal at the same time, and it may be useful to comprehend the Presocratics' conception of everything being mixed in everything.

This knowledge concept of fluidity among substances probably led western Anatolian crafters to the issue of alteration from a very early period. As the basics of metallurgy were comprehended at a very early stage, they were able to do experiments for new techniques with their extended knowledge. The distinction between metalworkers and sorcerers begins here in order to determine the extent to

which those who can be classified as chemists knew about these issues. The epistemologies of magic and technique are different. One can contend that they are parallel lines even though they are not the same. Those who were engaged in mass production can therefore be paired with Hephaistos, whereas those who cast spells on substances can be compared to deities who exhibit transformations, such as Hermes. In the early centuries, it was known in Roman society that certain individuals known as "mercenary sorcerers" had been employed by wealthy citizens to carry out investigations under their patronage, apparently for their benefit. It is difficult to ascertain the entirety of the patrons' requests, but it is likely that the expectations involved money. The manifestation of metallurgical alteration, commonly known as alchemy, likely resulted in the production of counterfeit coins as an initial outcome of such experiments.

The Medieval teaching referred to as "alchemy"²⁰ will make a substantial contribution to the comprehension of this distinction. The texts from Pseudo-Demokritos (the basis of the later alchemical corpus) elaborately display how the origins of alchemy can go back to the first millennium BC. Those "sorcerers" used a variety of techniques to modify the properties of metals, including alloying, blending with diverse metallic substances, and incorporating organic materials, primarily plants, to achieve various alterations. A formula from Pseudo-Demokritos shall display in depth:

²⁰ The term "alchemy" originates from the Old French word "alkimie". The term "alchemy" is believed to have originating from the Ancient Greek word *χημεία*, and subsequently passed through Arabic *كيميا* before being adopted into Medieval Latin and English as "alchymia" and "alchemy," respectively (Wiktionary, n.d.).

Take white magnesia: whiten it with brine and scissile alum in sea water, or with juice - I mean citron juice - or with sulphur vapour. For sulphur fumes whiten everything since they are white. Some people claim that kobathia fumes whiten it [i.e. magnesia] as well. After whitening, also mix an equal amount of wine dregs with it (i.e. the sulphur), so that [the magnesia] turns extraordinarily white. Then take four ounces of whitish copper - I mean of brass - and melt it by adding gradually one ounce of previously purified tin; stir with your hands until the substances join together:" it [i.e. the metallic alloy] will be breakable. So, add half of the white drug and it [i.e. the alloy] will be of first quality. For whitened magnesia does not let the [metallic] bodies break, nor the blackness of copper (lit. 'the shadow of copper') come out. Nature masters nature. (Martelli, 2013: 107)

This is a procedure for the making of silver and is intriguing in too many aspects.

The whole passage appears to describe a metallurgical procedure involving the refining of copper and tin to create a metallic alloy. It suggests that the copper should be a whitish color (likely indicating brass) and that it should be melted and combined progressively with purified tin while stirring until the substances combine. The resultant metallic alloy will be fragile but can be fortified by the addition of the white substance.

Not only the metals but also the plants are significantly related to culture in the formulae from Pseudo-Demokritos. Saffron, a widely utilized plant for producing a golden hue, holds significant cultural and historical significance. It has been associated with the folkloric plant *prometheion* and was employed by the well-known sorceress Medea to tremble the earth (Lindsay, 1970: 84), and it is no coincidence that it is a common ingredient in alchemical formulations. This plant was also cultivated in Sardeis, on Mount Tmolos (Solinus 40.10), and it is significant that there is a temple of Artemis there: in the cult of Rhea in Crete, which we associated with the mines, young girls gathered saffron for her, and this custom was

transferred to Artemis in Brauron (Davis, 1986: 403). This cult practice may have originated in the alchemical tradition of Anatolia.

All the written sources about elements and metals come from philosophical and medical texts. However, these texts were written by literate and sophisticated people who I shall name “sorcerers” in the concluding chapter. Nevertheless, the tangible artifacts can (and must) well be investigated within an archaeological framework to display that the mere metalworkers also knew these though they did not write manuals.

CHAPTER 6

METALWORKING TRADITIONS IN SELECTED REGIONS

I have displayed the geological formation and geographical borders of western Anatolia, the natural resources they bear, their locations, the techniques to extract them from ores and initially produce metal items so far. Now, we are able to discuss the material data at hand in relation to ancient folklore regarding certain sites (Map 3).

6.1 Mysia

Chapter 4 explained the modern bias that suggests the production of brass did not significantly increase until the 1st century AD. However, there exist samples of brass artifacts from earlier periods in western Anatolia, as well as testimonies regarding *oreíkhalkos*.

Although the meaning of the word has been debated, it appears to refer to brass, which the ancients learned to make by fusing zinc ore (cadmium, calamine). Smith's article in *A Dictionary of Greek and Roman Antiquities* asserts that it seems unlikely that the ancients were familiar with brass as a metal. He suggests that they believed it to be a type of bronze, which is a reasonable assumption to make. He defends this supposition by arguing that their ignorance of the metal's precise composition is

demonstrated by the fact that they were deceived by its color and thought gold to be one of its constituents. Consequently, they then perpetuated their mistake by giving it the incorrect spelling aurichalcum (*oreíkhalkos*) (William Smith, 845). Although this suggestion should apply to the common people of antiquity, one can argue that the Mysian metalworkers knew better. It should also be noted that the misinterpretation of brass may have resulted from ignorance of the early modern period: Johnson defines bronze as brass in his Dictionary (1755) from the 18th century, and the terms were used interchangeably in England until the 19th century.

To display brass' cultural role in Ancient Greek literature, the best example is the narrative of Atlantis by Platon:

The entire circuit of the wall, which went round the outermost zone, they covered with a coating of brass, and the circuit of the next wall they coated with tin, and the third, which encompassed the citadel, flashed with the red light of *oreíkhalkos* [ὀρείχαλκος].” (Plat. *Tim.* 116c.)

For brass, he uses the word *ὀρείχαλκος* (*oreíkhalkos*), which literally translates to “mountain copper.” The ancients valued this metallic compound. According to Craddock and Eckstein (2003), the Greek word *oreíkhalkos* is derived from a Hittite one that potentially refers to brass as “the copper of the mountain.” In addition, the etymology of the ancient Mauryan word for brass, *arakuta*, suggests that this alloy was introduced by Aleksandros III, as the word is a Greek loanword.

It is a plausible time to go back to the plains of *Gorgon*. Even though the mythological tradition puts them in Libya, myth is not bound to locations and geography. The most important classical attestation about the production of brass

was made by Strabon when he was describing the Gargara region, the vicinity where Kisthene is:

About Andeira is found an ore which when roasted becomes iron. Then, when treated in the furnace with a certain earth, it distills mock-silver [ψευδάργυρος], and this, by the addition of copper, becomes the so-called alloy, which some name brass [ὀρείχαλκος]. Mock-silver is also found near Tmolos. (Strab. 13.1.56)

The site of Gargara is still disputed. However, it must be in the southern coast of Troas somewhere between Assos and Antodros where zinc deposits are abundant in the chersonese. The term "Ψευδάργυρος" (*pseudargyros*) means "false silver" or "counterfeit silver" (Logeion, n.d.) It might be referring to zinc here.

The theory assuming ancients were not able to produce brass is based on the assumption that solidifying the zinc vapour before it oxidizes was a major problem for the ancient smiths. Craddock (1987: 190), on the other hand, displays a case study from a distant land but earlier time period: the brass industry of Zawar in India. The furnace used there is illustrated as follows: the fire and retorts were in the upper chamber, and the zinc was gathered below, as opposed to a fire beneath to heat the pots stacked above via the perforated floor.

In contemporary terms, for the conversion of calamine into metallic zinc, the ore must be roasted. The carbonate is changed into zinc oxide through this procedure. The oxide is then combined in some way with charcoal in a crucible, where the metallic zinc is subsequently distilled. This method would require a modern zinc furnace. Yet, Walter Leaf had the suspicion that in an ancient furnace, the vapor of zinc could be accidentally condensed in cracked in the walls of the furnace and

trickle down drops (Leaf, 1914: 27). This assumption also resembles the technique used in the Zawar example above. Although Mysia lacks archaeological evidence for now, there are findings of zinc droplets in various regions, such as Aachen in Germany (Craddock & Eckstein, 2003: 218), which presents similar characteristics to the ores found in Mysia, Lydia, and Phrygia. Thus, an accidental incident might have introduced a new technique for the Mysians to produce *oreikhalkos*.

Moreover, Leaf asserts that the discovery might have stemmed from an endeavor to create silver from zinc, two elements of which Mysia was rich. However, if this is the case, it still does not explain why Strabon claims that this metal transforms into iron when heated. Here, Leaf proposes two explanations, the second of which is both intriguing and logical. This was either due to Strabon's lack of expertise as a professional metallurgist or because the metallurgists in this region may have been determined to conceal their art. Furthermore, zinc ores were associated with iron. It is possible to draw some conclusions about Mysia by knowing that iron was considered an unholy metal in both classical Greece and Rome. Iron's unholiness was largely a result of its unfamiliarity and long existence in the Bronze Age as a metal whose source is almost exclusively meteoric. Even if the iron industry advanced later, this archaic “foreignness” remained. It is known that when iron was brought in, *brass* was used to purify the temples in Ancient Rome (Bailey, 1932: 24) . It is conceivable to suggest a very intriguing allegory for Medusa regarding the relationship between these two metals due to the necessity to purify.

6.2 Lydia

Sardeis presents a perfect example for the theoretical framework I have displayed so far. In ancient Sardeis, several metals were used, including copper, iron, gold, silver, lead, tin, and zinc. Copper was the primary metal, while tin and zinc were primarily used as alloys with copper. Some of these metals were available locally, while others had to be imported. Atomic spectrography, neutron activation, and atomic absorption (methods that allow identifying certain elements and determining their concentration in samples) are utilized to conduct archaeometric analyses. For the more exceptional alloys in Lydo-Persian and Hellenistic periods, the study conducted an analysis of eleven objects including the ibex plaque (catalogue number²¹: 87), a sealing (uncatalogued), a bowl (487), a straight pin (660), two fibulae (672, 674), and five arrowheads (20-22, 29 and 34) of Lydian or Persian origin (Waldbaum, 1983: 170). The objects were analyzed using two methods, ES and AA (emission spectroraphy and atomic absorption). The results from ES showed that tin was the major alloying ingredient in all objects, with significant amounts of lead in five samples (674, 20, 21, 22, 34) and arsenic in another five (660, 672, 674, 22, 34). None of the samples tested by ES contained significant levels of zinc. The study also found that all three objects tested by AA contained lead as the major alloying ingredient, while only two contained tin (Waldbaum, 1983: 170). Several items related to cementation and gilding were discovered at the site, including a copper alloy die cemented with gold (948), a plaque, a jewelry mold (949), and four molds associated with cemented gold objects (950-953) (Waldbaum, 1983: 7). Ancient source mentions the gilded statues of Apollon, Artemis, and Herakles, made by Dipoinis and Skyllis and were taken by the Persians (Waldbaum, 1983: 8). For those, The Princeton Expedition yielded only

²¹ The catalogue numbers are given from Waldbaum, J. (1983). *Metalwork from Sardis : The finds through 1974* . Cambridge: Harvard University Press.

two archaeological pieces of evidence, a gilded horse ear, and toes from a human foot (Waldbaum, 1983: 7).

The addition of lead to bronze is mainly done to increase its fluidity during casting, but it does not improve the cast bronze's working properties and may even be harmful in excessive amounts. Lead may have been added to arrowheads to reduce the amount of expensive tin and copper in the alloy, making the products cheaper. It was previously believed that lead was not intentionally added to bronzes until the Hellenistic period, and the presence or absence of lead was considered a rough dating criterion. However, recent studies by Craddock and others have found significant lead contents in some samples dating back to the Early Bronze Age and in subsequent periods. In the 4th and 5th centuries BC, Daskyleion, which was located on Lydia's political periphery, also employed lead to mass-produce consumables like arrowheads (Kasar & İren, 2020). A table (Table 2) is provided to display the percentages of lead in some copper alloy artifacts from Sardis. It shows that while lead was not used as an alloying agent in the Early Bronze Age, its usage began in the 6th-5th centuries BC. These first steps to include it as an alloying agents seems experimental as the later items (Hellenistic-Roman, Late Roman and Early Byzantine) have considerably higher percentages of lead.

Money in the form of coinage is just one -and relatively new mediator in trade. Value is a form of labor expressed in a variety of ways. Before the invention of coinage, trade was effectively done through other mediators. Barter economies are the oldest

known exchange systems that were dependent on reciprocal gifts²². However, this does not indicate a random sense of exchange among goods. Homeros describes it very well: In his *Ilias* and *Odysseia*, the values of goods are always equated with other goods as their *price*²³. The valuation of commodity x can be expressed in the form of y, z, and countless more. Aristoteles was the first to contemplate this, asserting the money form of the commodity is just an advanced expression of its equivalence to another thing. He further gives an impressive example: “*five beds for a house—since there is no real difference between that and the price of five beds for a house*” (Aristot. *Nic. Eth.* 1133b.25) (5 beds = 1 house = x amount of money). Ultimately, Karl Marx (1867: 82) concluded that the common mediator was human labor and value is a form of labor expressed in a variety of ways. That said, metals gain their value both because of their rarity and hardness to extract²⁴, which should explain why gold and silver *actually* have anthropologic values. However, their value is beyond price as they become the determiner of price itself due to their aforementioned features. Coming back to the Lydians and their various metal deposits possessions, Alain Bresson (as cited in van Alfen & Wartenberg, 2020: 9) argues that there was also a strong desire to establish a stable exchange ratio between gold and silver. The reason behind it was to prevent fluctuating exchange rates that could potentially destabilize the currency system, which has historically been a persistent issue in bimetallic currency systems. He concludes that coins could have potentially offered an elaborate resolution for avoiding the aforementioned issue. In

²² For further ethnological reference, see: Malinowski, B. (1922). *Argonauts of the western Pacific: an account of native enterprise and adventure in the archipelagoes of Melanesian New Guinea*. London : New York: G. Routledge & Sons.

²³ As a further reading, see: Donlan, W. (1989). The Unequal Exchange between Glaucus and Diomedes in Light of the Homeric Gift-Economy. *Phoenix*, 43(1), 1–15. <https://doi.org/10.2307/1088537>

²⁴ Even Herodotos seems aware of that when he discussed how the most valuable resources had to be brought from the farthest corners of the world.(Hdt. 3.115).

conclusion, this might be the reason behind the usage of electrum rather than gold or silver for the first coinage.

For the case of forgery, another Lydian item category is vessels along with coinage.

The classical sources frequently referred to the wealth of the Lydian kings.

Herodotos' account on the gifts sent by Kroisos to Delphoi is as follows:

When these offerings were ready, Kroisos sent them to Delphoi, with other gifts besides: namely, two very large bowls, one of gold and one of silver. The golden bowl stood to the right, the silver to the left of the temple entrance. These too were removed about the time of the temple's burning, and now the golden bowl, which weighs eight and a half talents and twelve minae, is in the treasury of the Clazomenians, and the silver bowl at the corner of the forecourt of the temple. (Hdt. 1.51)

On the archaeological ground, however, no spectrographic analysis done on the site of Sardeis reveals gold or silver vessels (Waldbaum, 1983: 87). The Harvard-Cornell Expedition has registered 89 objects of metal, and they are copper, bronze or brass (Waldbaum, 1983: 87). That is not to say that all the Lydian treasures were forgery, but, in the absence of modern archaeometric techniques, it should not have been simple for the layman in antiquity to distinguish imitation from the real. Herodotos also claims that during his own time, rare metals like gold and silver were brought to the Aegean region from the "furthest corners of the world" (Hdt. 3.115).

The case of gilding had been observed by Haedeke in his *Decorative Arts*. He presents many liturgical items along with vessels that were copper or brass gilt in order to imitate the shining appearance of silver and gold (Haedeke, 1970: 25-26). Although his examples from the Medieval Era come from a much later period and place(s), the assumption about the smith's themselves can find plausible parallels in

the case of western Anatolia during the 1st millennium as the written records he presented are absent from this region but can perfectly fit. It is significant that the guild of goldsmiths in London in 1370 forbade the production of copper gilt and brass gilt items (Haedeke, 1970: 21). They were treasured as highly as gold and silver. Haedeke asserts that the same case for antiquity, and both literary and archaeological evidence tend to confirm this. The distinction between “gold” and “gilded” in Ancient Greek is not always clear, for instance²⁵. While Cyprian Broodbank (2014) asserted for the Aegeans that they tried to imitate the visual features of metals as a means of strengthening their trade power, Michael Vickers (1985) did a detailed examination of Athenian pottery with the same sense.

If read carefully, ancient sources provide valuable insights for discussions on the historicity of ancient objects. When talking about the Lydian artifacts, Herodotos (I.50) employed the phrase "refined [ἄπερθος] gold" (Logeion, n.d.) to define them. According to Waldbaum (1983: 16), who categorized the terms the ancient historian used as adjectives for Lydian artifacts and archaeological findings, the term "refined" may have referred to the process of adding silver. As she includes in her commentary, in his *Onomastikon*, Polydeukes (7.98) also uses the same adjective for the coins of the reign of Gyges, the first king of the second dynasty from which stock Kroisos came, implying that the refinement was present when the minting of coinage started, proving Bolin's methodology described in Chapter 2.4. right.

Among the archaeological items Okrostsvaridze displays in Kolkhis (2018: 24), there is a golden ram's head from the Early Iron Age. This iconography must be connected

²⁵ χρύσεος could mean both (An Intermediate Greek-English Lexicon, n.d.).

to *Argonautika* given the central theme of the narrative and the objects with ram skulls found in Kolchhis pointing to a cult associated with this particular animal symbol. It is interesting to note that Phrygia and Lydia are two of the oldest cultures in Anatolia to use this imagery. This style had been labeled as having an eastern influence. Yet, many of the Iron Age items with the depiction of a ram's head had preceded the Persian invasion and the style of rams with their golden fleeces has representation on Lydian metalwork in western Anatolia in the early sixth century (Dusinberre, 2002: 41). Dusinberre had made a thorough investigation of an ivory panel from The Test Trench 15 from the excavation of Kerkenes and came to the conclusion that the iconography was local contrary to the previous assumption that linked it to Median art (Dusinberre, 2002: 41). Furthermore, he even proposed that the production of ivory artifacts in Kerkenes might have been inspired by raiding people (like the Scythians) coming from Transcaucasia (Dusinberre, 2002: 21). Considering Okrostsvaridze's observation that the essence of *Argonautika* was present in the Caucasus as it is supported by the ram iconography, this can serve as a bridge between cultures as a westwards movement. This is simply an assessment, however, given the lack of additional information and the fact that a ram's head may relate to a multitude of symbolisms. Yet, the items discussed in this context have never before been thought of in this context.

Theophrastos (*Lap.* 45; Caley & Richards, 1956: 156-7) asserts that the source of all touchstones was the "River Tmolos," which is likely an error for Mt. Tmolos (The Archaeological Exploration of Sardis, n.d.). Plinius (*Nat.* 33.126) cited Theophrastos and described the stone as Lydian (as cited in The Archaeological Exploration of Sardis, n.d.). From a Lydian home that was devastated in the middle of the sixth

century BC an abundance of touchstones (Area 1, including Nos. 62, 64, 65, 66, 68, 72, 73, 75, 81, 87, 88, 96, 97, 100, 102, 103, 137, 138) were found (The Archaeological Exploration of Sardis, n.d.). Since there is no indication that the house's occupants were metallurgists, Cahill (The Archaeological Exploration of Sardis, n.d.) suggests that discovery implies the common Lydians had good reasons to assay gold.

Sardeis also contains evidence of Early Iron Age ironworking. The EIA layers from the deep “Lydian trench” in sector HoB by the Lydian fortification wall uncovered numerous iron finds including three knives, a curved sickle blade, an adze blade, two double hooks, and a nail date to the tenth century BC (Ramage, Ramage & Gürtekin-Demir, 2021: 40–6, 137, 143, 156, pls 9 [cat. no. HoB 37: knife], 25 [cat. no. HoB 101; knife], 28 [cat. no. HoB 119: adze = Waldbaum, 1983: cat. no. 127], 53 [cat. no. HoB 236: knife = Waldbaum, 1983: 172; cat. no. HoB 237: sickle = Waldbaum, 1983: 118], 53 [cat. no. HoB 238: hook], and 40 [n. 14: nail, uncatalogued and n. 16: double hook, uncatalogued]) (as cited in Mokrišová & Verčík, 2022: 153-4).

Sardeis and Klazomenai are the best-preserved examples of metal workshops from Iron Age western Anatolia. The available evidence indicates that both were in industrial districts (Cahill, 2010: 88; Cevizoğlu & Yalçın, 2012: 75)²⁶. In Sardeis, for instance, spaces adjacent to the other large Roman buildings were also used as workshops. Although raw materials like slag and the products of metal workshops can be found in many settlements, it is uncommon to find a workshop that has been

²⁶ By industrial, however, not a modern sense should be considered. These places were in the lower city where the common people lived and conducted their economic activities at the same time.

excavated along with its facilities, equipment, and installations (such as anvils and hearths) along with the products (Cevizoğlu & Yalçın, 2012: 76).

Drainage channels and water supplies are extremely common installations in an industrial neighborhood and may indicate the presence of a work area. A water channel discovered during excavations in the HBT Field Sector at Klazomenai runs northwest to southeast. It utilized the north wind to its advantage (Cevizoğlu & Yalçın, 2012: 76). Multiple fragments of slag and a few pieces of iron tools that were recovered belonged to the workshop. Even steel was produced there, as indicated by the remnants of a refined bloom (Cevizoğlu & Yalçın, 2012: 79-80).

Cevizoğlu and Yalçın correctly assert that the tradition of metalwork in western Anatolia goes earlier than the Iron Age, and they see the finds from Liman Tepe as a good potential to link the tradition even earlier (Cevizoğlu & Yalçın, 2012: 78).

6.3 Phrygia

Muscarella and Vassileva only refer to the various fibulae as "bronze," which is a generic term for a variety of copper alloys, without providing any precise information regarding the alloys employed in their manufacture (Rademakers, Rehren & Voigt, 2018: 1669). Yet, Arthur Steinberg conducted a study on fibulae dating back to the 8th and 7th centuries BC in Gordion and concluded that they were composed of copper with an estimated zinc content of 10% and negligible quantities of tin or lead (Craddock, 1978: 3). The utilization of X-ray fluorescence in the examination of fibulae discovered in Gordion, along with other artifacts originating

from Phrygia and East Greek artifacts, has yielded additional findings indicating the existence of zinc. The high percentage of zinc in fibulae is not attested anywhere else. Craddock even proposed that maybe ratios of zinc might be the determiner for Phrygian craft for objects in general (Waldbaum, 1983: 170).

As mentioned in folklore, the Greek world was aware of the Phrygian origin of certain metal inventions. Archaeological evidence from the Aegean region demonstrates that not only fibulae, but also various Phrygian-style objects such as belts, were worn as daily attire and dedicated to sanctuaries (Vassileva, 2014: 230).

CHAPTER 7

CONCLUSION

After the revival of metallurgy in the Early Bronze Age, local cultures in western Anatolia began to grow as political entities. Due to the region's geological and geographical features, these cultures were separate and each had different mysteries related to the dominant elements in their region. In my investigation, I suggested that the ancient Mysians were faking silver and producing brass with the present methods they had, confirmed that the Lydians were capable of metal alteration from a very early period, and the Phrygians also probably had a way of producing zinc on a large scale²⁷. These enterprises left their traces both in mythological and historical narratives, on their folklore, so to speak. More importantly, the actual extent of ancient knowledge can be spotted in philosophical texts, especially those dwelling on the procedures that would later be labeled as “alchemy.”

There was a strict distinction between the mass producer and experimenter, who one can call either a sorcerer or conjurer. That is why Theophrastos, who merely wrote on stones was not defined as an alchemist, but Platon was (Lindsay, 1970: 93): he was interested in divine transformations, not just the materials. Thus, the second

²⁷ A chart (Figure 1) is provided to display the items containing lead and zinc as alloying agents found in the model sites from the 1st millennium BC. Since the number of zinc items from Gordion is never published, their number on the graph (172) is estimated. This estimation is based on the number of the fibulae on which the unpublished analysis was conducted (Iron Age Gordion, n. d.).

distinction can be made: not every metalworker was the same. Those who followed this school of metalwork, namely sorcerers, had a different identity than the mere smiths. And theirs was a profession: there are records from the Roman age that include some “mercenary sorcerers” with prominent citizens (Dufault, 2019: 19) who was probably interested in their “alchemical” enterprises. Nonetheless, either a mere smith or a “sorcerer,” they used the basics of the same craft and had to be acquainted with the chemical composition of elements.

As is said, alchemy was not a fantasy to create gold from nothing as the modern misconception suggests. It is probably due to the exclusion of esoterism from modern science when it was separated from alchemy. Rather than an impossible quest, alchemy was more about the essence of precious metals. It paved the way for natural sciences. It was the knowledge of all the metals and minerals, and the accents of alchemists or sorcerers were indeed capable of combining those materials in different manners. Archaeological evidence of common items observed in this thesis shows that not just the sorcerers but also the mere crafters had some kind of knowledge of this, as is shown in their irregular alloys. They indeed used agency with a knowledge of the esoteric epistemology of minerals. The main issue with the smiths pertains to the lack of writing records by their hands, so the archaeologist can only assume through their experimental enterprises in archaeological data or attempt to perceive their self-image from the literary traditions they might have been familiar with. Although not mere smiths themselves wrote on metals, the literary traditions they may have heard (or even read) are able to present clues for their self-image. As is discussed in Chapter 5, if they sought to create artifacts with deep meanings, this would imply an intellectual endeavor. Ultimately, the association of a metallurgical

corpus from the Hellenistic Age with the Greek god of knowledge (Hermes) can be read in a better light. Hermes Trismegistos could have been the self-portrait of metalworkers. While the image of Hephaistos would probably portray their physical appearance, Hermes may be their idealized intellectual portrait.

The percentages of elements alone cannot show us everything for the simple fact that alchemical recipes were not only about casting metals! They contained organic materials, too. In the end, it is plausible to offer that in western Anatolia, there was a tradition that can be labeled as “Proto Alchemy²⁸” and though scant, we have its traces in the archaeological record. To enhance the evidential basis, not only characterization but also organic material analyses are necessary on irregularly alloyed artifacts. It should also be noted that the scope of analyses ought to shift towards ordinary metallic items as well. As Craddock and Eckstein also pointed out, contrary to the majestic works of the time, everyday items from the peripheries of the Hellenistic world exhibited a widespread utilization of brass from a relatively earlier period of its mass production (Craddock & Eckstein, 2003: 217).

Archaeological metalwork analysis offers essential insights into the evolution of science history. Particularly, the field of metallurgy serves as a significant indicator of technological advancements and societal progress. While earlier research mainly claimed that the Levant and Cyprus impacted Greece's Iron Age metalwork, it is now clear that western Anatolia had an extensive tradition of metalworking that substantially influenced Ancient Greece and transferred its philosophical deliberations to it. The reflection of those deliberations on semi-literate people like

²⁸ The term was first used by Jack Lindsay (1970).

smiths can be best guessed from the folk tales, which is why when dealing with ancient sources, I gave weight to travelers like Herodotos, whose audience was the common folk. Therefore, based on what is known about the Ancient Greek comprehension of physics, it can be suggested that the understanding of mineralogy in western Anatolia during the 1st millennium BC significantly contributed to the accumulation of scientific knowledge in the Aegean. This knowledge (further developed and compiled by Aristoteles), contributed to the emergence of the scientific tradition during the historical period known as the Greek miracle or Axial Age.

Numerous Bronze Age sites with an uninterrupted connection to Iron Age may be found in western Anatolia, providing a wealth of material that can be used to establish concrete links between different metalworking techniques over time. By employing the methodology presented in this thesis, it becomes possible to establish those connections while considering their contemporary context and grounding in philosophical deliberations. These interconnections can be further elucidated through future archaeometrical analyses and historical/philosophical investigations.

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TABLES

Sestertii minted under emperors	Time periods	Ratio [%]	Cu	Sn	Pb	Zn
Claudius	(41–54 AD)	<i>Klaproth</i>	77,9	–	–	22,1
		Riederer	77,5	–	0,2	21,6
Vespasianus	(69–79 AD)	<i>Klaproth</i>	81,4	0,8	1,1	16,4
		Riederer	81,3	–	0,13	17,4
Traianus	(98–117 AD)	<i>Klaproth</i>	83,0	1,9	–	15,15
		Riederer	83,3	0,7	0,62	14,45

Table 1 Comparison of analyses by Klaproth and Riederer on Ancient Roman coins (Bartel, 2017: table 1)

Catalogue Number	Type of object	Date	Pb
656	Pin	Early Bronze	0.23
674	Fibula	Archaic	1.18
18	Arrowhead	6th-5th C.	8.04
19	Arrowhead	6th-5th C.	15.0
20	Arrowhead	6th-5th C.	2.27
30	Arrowhead	6th-5th C.	7.53
39	Arrowhead	Hellenistic -Roman	26.9
264	Plumbing fixture	Late Roman	21.7
583	Censer	Early Byzantine	20.4

Table 2 Analyses of alloying elements in copper alloy artifacts (in percent)
(Waldbaum, 1983: table V.4b)

FIGURES

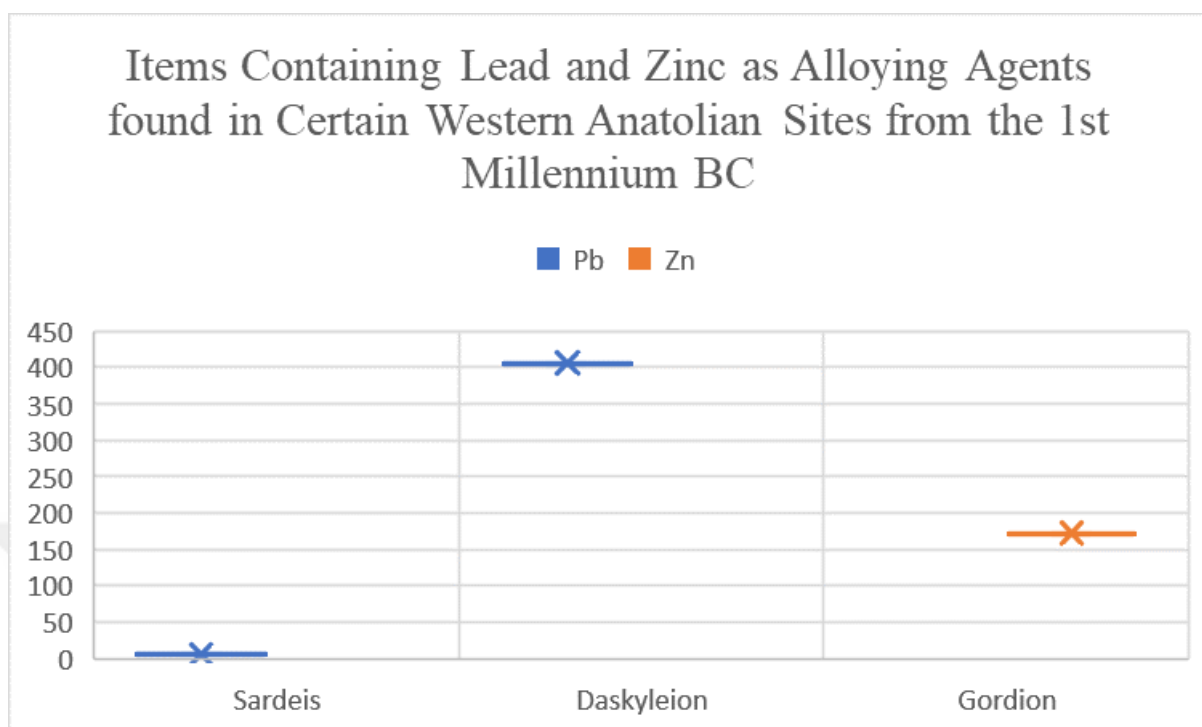


Figure 1 Chart displaying the items containing lead and zinc as alloying agents found in the model sites from the 1st millennium BC

MAPS



Map 1 Map of western Anatolia (Courtesy of Yiğit Pekzeren)



Map 2 Map of the model regions (Courtesy of Yiğit Pekzeren)



Map 3 Model sites discussed in the text (Courtesy of Yiğit Pekzeren)