A STUDY OF LEAD INGOT CARGOES

FROM ANCIENT MEDITERRANEAN SHIPWRECKS

A Thesis

by

HEATHER GALE BROWN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

August 2011

Major Subject: Anthropology

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Approved by:

Chair of Committee,	Deborah N. Carlson
Committee Members,	Cemal Pulak
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ABSTRACT

A Study of Lead Ingot Cargoes from Ancient Mediterranean Shipwrecks. (August 2011)

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Chair of Advisory Committee: Dr. Deborah N. Carlson

Lead is often relegated to a footnote or sidebar in the study of ancient metals. However, the hundreds of lead ingots discovered in underwater sites over the past half-century have attested to the widespread production and trade of this utilitarian metal. Shipwreck sites allow independent dating evidence not available for many land find. They also provide information about shipment size as well as accompanying cargo which can offer clues about trade patterns and markets for lead in the ancient world. While lead was not particularly rare nor valuable, it represents small- to moderate-scale trade that bridges the gap between luxury trade and the circulation of staple agricultural products. It thus can be viewed as a proxy for the many other perishable materials that supported daily life, such as timber, cloth, cordage, leather and pigments.

Due to the abundance of lead ingot finds, published in many different languages with great variation in the details provided, it is difficult to compare all of this material. This thesis, therefore, compiles and presents data on all published lead ingots from Mediterranean and Atlantic shipwrecks through the fourth century C.E., in order to provide a framework to analyze the ancient seaborne lead trade. Sixty-eight sites containing lead ingots, lead ore or lead minerals are included in the analysis, divided into six time periods: Bronze Age, Archaic, Classical, Hellenistic, Roman Republic and Roman Empire. A typology of ingots has been developed to allow for comparison of ingots between wrecks. The uses of lead are reviewed, organized by type of use: domestic, professional, military and infrastructural. This allows insight into both the consumers in need of lead and the volume and regularity of consumption required for each use. An overview of lead production and its economic limitations further informs the discussion of the lead trade. The final analysis considers all of these factors in

creating a picture of lead trade for each of the six periods, focusing on the regions of supply, the types of demand, and the dominant forces that drove the mining and production of lead.

DEDICATION

To my parents, who never told me I was crazy to quit a perfectly good job to go to grad school. Thank you for your love and support.

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I would like to thank my committee chair, Dr. Deborah Carlson, for her interest in this topic, her guidance, and her unfailing encouragement of my research. I would also like to thank Dr. Cemal Pulak for sharing his time and expertise in the area of ancient metals, even if lead isn't as exciting as copper.

Additional thanks are due to the many scholars who kindly shared their knowledge and their work with me over the years, including Susan Katzev, Mark Polzer, Dr. Nancy Klein, Dr. Marcus Hermanns, Dr. Irina Radic-Rossi, Dr. Marie-Pierre Jézégou, Dr. Wendy van Duivenvoorde, and Dr. Richard Griffin.

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CHAPTER I
INTRODUCTION

Emptor Salve

– Anonymous

Emerging from the dull, dark grey block of metal in sharp, even letters are the words *Emptor Salve* – Greetings, Buyer.[1] This two-thousand-year-old message from an unknown Roman entrepreneur bears witness to a thriving commercial activity in lead in the ancient world. Lead does not capture the imagination in the way of gold diadems or silver coins, iron swords or bronze statues, but it has been processed for millennia, traded over thousands of miles, and used in countless small ways to facilitate the daily life of people rich and poor, great and small.

Archaeological evidence of the ancient lead trade has increased greatly over the last half century, allowing us to see where it was mined and produced, how far it was shipped and how it was consumed. Lead offers a unique perspective on commercial practices of the ancient world because it was both so important and yet so ordinary. The economic power and technological knowledge required to mine and refine metal limited the number of people who could participate in its initial production, and yet, once refined, its malleability, ductility, and low melting temperature limited the need for specialists in the vein of blacksmiths and bronze casters. By tracing a commodity that was derived from limited, though not rare, resources, which was closely tied neither to agricultural production nor prestige industries, we can begin to see how the ancient economy was able to integrate small scale trade into a framework supported by larger scale consumers in order to fill the needs of a broad spectrum of the population.

Despite a large body of scholarship on the subject of ancient lead, several aspects are frequently ignored or glossed over in the literature. First, since lead ores usually

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This thesis follows the style and format of the *American Journal of Archaeology*.

[1] This inscription was found on several lead ingots from the Sud Perduto B wreck (see Appendix A, **45.42-48**.)

contain silver, discussions of lead are often tacked on to studies of silver mining and provenience, and do not consider lead as a commodity in its own right.[2]

Second, due to the overwhelming amount of evidence from the Roman period, trade in lead in earlier periods tends to be treated as minimal. When a specific pre-Roman lead find is published, there is usually a quick overview of the possible sources of the metal and a brief mention of the most prominent types of use in the relevant period, but there are often few comparanda with which to make complex analyses.[3] In studies of Bronze Age metals, in particular, lead is eclipsed almost entirely by copper and tin.

Another problematic area is the variety of applications for lead, which are frequently enumerated or summarized, based primarily on archaeological finds, but with little deeper examination of who and where the consumers were. This is understandable, for its many and varied applications make it difficult to condense the full picture into a few sentences or even paragraphs. Scholars who have spent time detailing lead uses include William Pulsifer,[4] who was concerned with applications of lead in art, and Jerome Nriagu,[5] whose ultimate aim was to relate lead use to exposure to lead poisoning.

Discussions of lead uses, furthermore, are generally not organized chronologically to show development over time. While they often start with the earliest uses first, they do not follow regional or temporal trends in any format that allows useful comparative analysis. Thus, the economic implications of the lead trade are rarely correlated with types of use and the regions in which they are practiced. By looking at patterns of use over time and by establishing broad categories of use within a culture, one can begin to identify trends in the economic control of lead resources and the demand that may have driven it.

[2] Forbes 1950, 169-230; Gale 1980; Stos-Gale and Gale 1982; Yener 1986; Moorey 1994, 293-297.
[3] Eiseman and Rigdeway 1987; Hermanns (in press); Muhly 1988.
[4] Pulsifer 1888
[5] Nriagu 1983

INGOTS

Our best evidence for lead as a commodity is the ever-increasing number of ingots that have been found at both land and underwater sites in Europe, North Africa and the Near East. From an economic standpoint, ingots represent an important intermediate stage in which the metal is being transferred from the hands of specialist producers into the various distribution channels that connected the product to the consumer.

The study of lead ingots has been taken up by many scholars over the years, with increasing complexity as the body of evidence has grown. Ingots from the Roman period with detailed cast inscriptions have been noted by scholars as far back as the 16th century C.E.[6] In most of these early examples, the inscriptions were recorded, but details about the dimensions, weight and condition of the ingots were omitted. In the early 20th century, several scholars published more detailed studies of lead ingots, though their task was difficult as they were restricted to examples in museums, many with uncertain or no provenience.[7] Beginning in the 1960s Claude Domergue began to study the lead output of Iberian mines of the Roman period in a more rigorous manner, considering not just the inscription as a historical record, but also the ingot as an artifact unto itself.[8] At that time the number of known ingots also began to expand exponentially due to the advent of SCUBA-based wreck excavation.[9]

The purpose of this study, therefore, is twofold. The first is to collect data from published accounts of submerged lead ingots from around the ancient Mediterranean in one document (Appendix A).[10] Over the years finds have been published in many different languages and many different formats, making broader regional or temporal comparisons difficult. Domergue himself has been compiling a detailed catalog of all the

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[6] For instance, *RIB* 2404.19 was recorded from an ingot found ca. 1530 C.E. in Wells, Somerset, England.
[7] Gowland 1901; Besnier 1920, 1921a, 1921b; Beltrán 1947.
[8] See Domergue 1965, 1966.
[9] Among the earliest underwater excavations to involve archaeologists actually diving on the site was the Bronze Age wreck at Cape Gelidonya in 1960, which revealed a partial cargo of copper oxhide ingots that equaled half the total number of oxhide ingots known to that point (Bass 1961, 271-2).
[10] References made in the text to wrecks discussed in this appendix will be noted by a bold-faced number in parentheses in the body of the text, e.g. Porticello (**9**).

Romano-Iberian examples that have been located to date. Unfortunately, this document has been awaiting publication for many years. Until such time as his work is made available to the general public, the enclosed catalog is offered as a working document to allow easy reference to a wealth of otherwise disparate data. It is divided into six sub-sections based on time periods (Bronze Age, Early Iron Age and Archaic, Classical, Hellenistic, Roman Republic, and Roman Empire). The sites are organized in roughly chronological order, with poorly dated sites listed last in each sub-section. A brief summary of each site is included, describing the wreck context, additional cargo elements, the lead component, and any other significant lead artifacts. I have assigned a sub-number to each ingot for which details have been published, and included under these entries, where possible, ingot type, dimensions, weight, and full text of inscriptions. In some cases, only average measurements per batch were published, in which case a single sub-entry has been made for the batch as a whole. Due to my reliance on published accounts, it is understood that Domergue's work, once it is finally available, will be even more comprehensive because he has been able to re-evaluate many of the ingots since their original publication, correcting and supplementing data omitted from many published accounts.

The 68 entries in my catalog are, additionally, restricted to underwater finds. These are primarily shipwreck sites, although some isolated underwater finds are included.[11] This treatment is intended to emphasize the underwater contexts in which they were found so that we may focus more on issues of trade and distribution rather than production and mining organization, two areas already comprehensively addressed by Domergue and others.[12] On the other hand, while Domergue's work focuses on ingots of Iberian origin only, this catalog includes finds from the Bronze Age through the fourth century C.E., regardless of origin, in order to show that even though Roman lead

[11] As many of these sites were listed in A.J. Parker's (1992a) comprehensive catalog of ancient shipwrecks in the Mediterranean, his designation for the site, where applicable, has been retained here to avoid confusion. Any additional names for a site have been included under its main entry.
[12] Conophagos 1980, Whittick 1982, Edmondson 1987, Domergue 1990, 1998, Treister 1996, Rovira 2002, Hirt 2010.

trade was far beyond the scale of anything previously seen, it was nevertheless part of a continuum that started as far back as the Bronze Age.

The second purpose of this work is to examine more closely the contexts in which these ingots were found. This is an important area of analysis which, now that the sample size has grown sufficiently large, has primarily been attempted on a limited regional or temporal scale. For example, cargoes of Baetican origin with lead and amphora components have been used to explore Baetican commerce as a whole and its role in supplying the Roman Empire.[13] Frands Herschend examined three well-documented Roman ingot cargoes for patterns in their inscriptions in order to paint a broader picture of Roman merchant practices.[14] My intention is to use the full cargo as a context, where possible, to assess the types of materials being shipped together to get a better idea of the intended destination and consumers of the lead on board. In many cases there is not enough evidence to reach a solid conclusion, but there are enough well-documented shipwreck sites to make some inferences about overall activity in the lead trade during different periods.

In order to meet these research goals, I have examined three points along the distribution chain – consumption, production, and loss site. Chapter II is devoted to consumption of lead, based on uses known from archaeological and historical sources. This information has been organized by time period, to show the gradual increase in and diversification of demand for lead. Applications of lead have been grouped into categories related to the regularity and volume consumed, which can show how changes in demand affected changes in exploitation strategies.

Chapter III looks at the mining and production of metallic lead with an eye toward the economic factors that restricted and encouraged exploitation in various regions and periods. By looking at lead production not just from a history of technology perspective, but in terms of an operation subject to the normal business constraints of resources, labor, and competition, we can get a better picture of why certain ore bodies were exploited at certain times. Changes in viable mining zones had a strong impact on

[13] Liou and Domergue 1990; Domergue and Liou 1997; Domergue 1998.
[14] Herschend 1995.

the regions in which they were situated, and were often related to larger overall economic and cultural trends. Production activity has been broken into time periods in order to demonstrate that, despite the widespread occurrence of lead ores, political, social, technological, and economic circumstances contributed to the decision to exploit different resources at different times.

Chapter IV is an overview of what we know about ancient lead ingots. I have established a techno-functional typology based on shape and casting complexity, which allow comparison between ingots from different time periods and regions. Some of the difficulties in evaluating ingots from archaeological contexts are addressed in order to aid the reader in assessing the data presented in the catalog (Appendix A).

In Chapter V, wrecks with lead cargoes are presented, arranged by time period. Each cargo has been assigned a category, based on context, contrasting raw materials to finished products, and dedicated metal cargoes to mixed cargoes of metals and staple agricultural products. In doing so, I have focused on the types of markets the cargoes were most likely intended to have supplied.

The overall goal of this work is to assemble a dataset of lead ingots recovered from underwater sites in a single, organized whole. It is my hope that it will make this significant body of evidence more accessible to scholars and facilitate further awareness and study of the distribution of ancient lead. I have offered an example of how comparative shipwreck data may be used, in conjunction with other archaeological and historical evidence, to demonstrate the shifting patterns in the less visible, but dynamic realm of small-scale utilitarian trade that took place all across the ancient world. These transactions helped build cities and empires just as much as the luxurious gifts of kings and the massive shipments of grain to feed the urban populous.

CHAPTER II
THE WEIGHT OF DEMAND: USES OF LEAD IN THE ANCIENT WORLD

Quod superest, aes atque aurum ferrumque repertumst
et simul argenti pondus plumbique potestas[15]

– Lucretius (5.1241-2)

In summarizing the most important steps in the history of mankind, Lucretius speaks of the discovery of metals – gold, copper and iron come first, being those most obviously associated with wealth, prestige and military force. To these three he adds silver and lead. The weight of silver he singles out, and the power of lead.

The importance of lead lay not in its beauty, its rarity or monetary value, but in its usefulness. Though wars were not fought for it, exotic trade routes were not forged to provide it, great works of art were not rendered from it, without it many of those achievements would not have been the same. From the lead bullets fired by slingers in battle, to the merchant vessels sheathed with lead, to the bronze of statues, made more fluid for casting by the addition of lead, the ancient world relied a great deal upon this humble metal. In contrast to the study of luxury goods or agricultural staples, an examination of lead provides an opportunity to study a non-subsistence commodity tied to market activity in which all strata of society participated rather than just the elites. A closer look at the channels through which lead passed may shed some light on the social and economic role played by lead in the ancient world.

Lead is attested in the historical record as far back as the Bronze Age and archaeologically as early as the sixth millennium B.C.E. Several detailed surveys of the uses of ancient lead have been compiled over the years, including Pulsifer's *Notes for a History of Lead* (1888), *Gmelins Handbuch der anorganischen Chemie,* Blei – Teil 1A (1973), Krysko's *Lead in History and Art* (1979) and Nriagu's *Lead and Lead Poisoning in Antiquity* (1983). These provide a wide variety of both historical and archaeological

[15] "As for what remains, copper and gold and iron were discovered, along with the weight of silver and the power of lead."

evidence which is too extensive to reproduce in its entirety here. This chapter provides a brief overview of the uses of lead in the ancient world showing its development over time to give the reader an idea of the extent and pattern of lead's penetration into Mediterranean lifeways.

Due to the broad geographical and chronological spread of the evidence, references to dates will be generalized into the following periods, based on the Near Eastern chronology, regardless of the region: Bronze Age: 3200-1200 B.C.E., subdivided into Early Bronze Age (EBA): 3200-2000, Middle Bronze Age (MBA): 2000-1550, and Late Bronze Age (LBA): 1550-1200; Early Iron Age: 1200-800 B.C.E.; Archaic Period: 800-510 B.C.E.; Classical Period: 510-336 B.C.E.; Hellenistic Period: 336-146 B.C.E.; Roman Republican Period: 146-31 B.C.E.; Roman Empire: 31 B.C.E. to 476 C.E.[16] Many of the abovementioned accounts of lead provide relatively loose or poorly organized chronologies for lead, with examples from many time periods mixed together. An effort will be made here to highlight a more linear progression of the development of lead usage.

PROPERTIES OF LEAD

Lead has several primary properties that have dictated its use throughout human history. Most notably, it has a very low melting point (ca. 327 ºC) making it easy to smelt, cast, and remelt without special furnaces or a heavy investment of fuel. Due to its high malleability at room temperature, it can be reshaped using simple tools or even by hand. While this prevents its use for structural elements or most types of tools, it makes lead an ideal material for bending and custom shaping, such as rolling into pipes or sheathing the hulls of wooden ships. Related to its malleability is its softness. So effortless is it to scratch its surface, that thin sheets of lead were often used in the ancient

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[16] Many scholars designate the end of the Hellenistic period as 31 B.C.E., when Rome finally succeeded in annexing Egypt; however, from a metals standpoint, 146 B.C.E., when the Romans destroyed Carthage and declared direct control of Greece, is more economically significant.

world as a form of stationery, carrying personal letters across the Mediterranean and Black seas.[17]

Many of the practical applications of lead are also facilitated by its resistance to corrosion. Although it often appears that lead does not corrode, it does, in fact, do so. Its most common corrosion product in natural and salt waters is lead carbonate, though sulfides often occur in today's polluted environments.[18] Lead corrosion products tend to form as a thin, impervious film on the surface of the metal which then protects the material from further attack.[19] This allows lead to remain relatively stable in many environments and gives it the appearance of incorruptibility.

The final useful property of lead is its density. Due to its tightly-packed crystal structure, it has a specific gravity of 11.35, second only to gold (19.3) as the densest metal known to the ancients. Unlike gold, which was rare and valuable, lead was abundant and cheap, making it the ideal metal for use in weight-based applications, such as fishing weights, anchor stocks and statue bases.

Lead and Silver

The pairing of lead with silver in Lucretius' introductory couplet is by no means accidental. One of the most common sources of silver is galena ore, also known as lead sulfide (PbS). Deposits of another lead-bearing mineral, cerussite (lead carbonate, $PbCO_3$), are frequently found with silver. These deposits are rarer than galena, but tend to have a higher silver concentration, and thus are believed to have been the primary source of much of Bronze Age refined silver, such as that from Anatolia which supplied the great empires of Mesopotamia.[20] Thus the history of lead is closely tied to the history

[17] Vinogradov 1998.
[18] Tylecote 1983, 400.
[19] Alhassan, 2005, 195.
[20] The probable widespread exploitation of cerussite as well as anglesite ($PbCO_4$) is supported by Craddock (1995, 212-14), but without a refined chronology; he suggests galena was only exploited for lead and not desilvered, as evidenced by ingots from Roman Britain, based on the low silver content of local galena samples. On evidence for Bronze Age Anatolia specifically, see (Moorey 1994, 233). P. Meyers (cited in Muhly 1988, n. 22) believes that galena was not exploited for silver until the Islamic period, though Muhly notes litharge from MBA levels at Thorikos which seems to contradict this. Conophagos (1980, 161-2) notes that while oxide ores were doubtless preferred at the Laurion mines when

of silver. The amount of silver varies from ore deposit to ore deposit, and even within a deposit itself, but is rarely higher than 5,000 ppm (0.5%) and is frequently much lower.[21] In many cases, therefore, silver mines produced a good deal of lead as a byproduct, often on the scale of tons of lead for mere kilograms of silver. Much of this, especially in pre-Roman times, was left unutilized in slag heaps, since transporting and recovering the lead cost more than the final product was worth.[22]

Another important link between silver and lead is cupellation. This is a method of extracting silver from ores as well as refining adulterated silver and gold for reuse, and was arguably the most important use of lead in the ancient world. Cupellation involves the oxidization of lead to form litharge (lead oxide, PbO), which takes with it impurities such as tin, copper, iron, antimony, arsenic, bismuth and zinc,[23] while leaving silver unaltered due to its resistance to oxidation at temperatures high above its melting point.[24] The silver-bearing lead would be placed in a hearth or cupel of clay, or later, bone ash, that had a wide opening for maximum oxygen exposure;[25] the metal was melted and air was blasted across the surface forming a crust of litharge that could be scraped off.[26] The process was continued, with more lead added as necessary, until only

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available, galena was also used by the ancients; again, no chronology is offered and he does not specify whether it was desilvered or simply smelted for the lead. Domergue (1990, 71-3), however, provides galena samples from Spanish mines with silver contents significant enough to have been exploited for silver in the Roman period, if not earlier. The difficulties of dating mine workings are addressed further in Chapter 2.

[21] Of the 59 samples of Spanish galena (from 42 different mines) tested by Domergue (1990, 72-3), only 15 contained more than 5,000 ppm Ag, and of those only 2 contained higher than 10,000 ppm. Tylecote (1992, 57-8) notes that silver content from Laurion ores contained up to 1,200-4000 ppm Ag, "the highest recorded in the pre-Roman period from the Near East and Aegean." It is possible, however, that richer ores were originally present and exhausted in antiquity. Stos-Gale and Gale (1982, 485) believe that the limit for EBA silver recovery was 800 ppm, while for the LBA it was 400-600 ppm. Pernicka et al. (1998, 129) state that the Romans achieved success with ores of 100 ppm, and even, as noted by Strabo (9.1.23), recovered silver left behind in slag from earlier silver production sites such as Laurion.

[22] Pulsifer (1888, 9) cites examples of both ancient and modern unexploited slag heaps in the Iberian Peninsula, the Ural and Rocky mountains, and Mexico.

[23] Stos-Gale and Gale 1982, 483. Any gold present will also remain with the silver, and must be separated by a separate process.

[24] Pulsifer 1888, 136.

[25] While many assume the medieval description of bone ash cupellation hearths in Agricola (Hoover and Hoover 1950, 230) also applies to ancient practices, Craddock (1995, 228) outlines the lack of evidence to support its use until at least the first century C.E.

[26] Conophagos (1980, 332-7) also points out a technique, perhaps developed by the Greeks, for removing litharge by dipping iron rods or green branches into the molten metal around which the litharge solidified;

a concentrated bead of silver remained.[27] The litharge thus produced was often considered a waste product, but it could be processed back into metallic lead at some expense. There was also significant loss of lead during the process, primarily through volatilization, reported by Pliny as 2/9, or approximately 22%.[28] If the cost of new lead was cheaper than reducing the litharge to metal, then the consumption of lead for the process could have been very high.[29] One must keep in mind that for every kilogram of silver refined a great amount of lead was both produced and required.

Alloys and Compounds

While there were many uses for pure lead, there were other, less obvious uses for the metal that also placed significant demands on the lead supply. Leaded bronze was probably the most common alloy. Documented through chemical analysis as far back as the Early Bronze Age, but only becoming common in the Late Bronze Age, bronze objects containing as much as 20% lead or more have been found.[30] Lead can occur naturally in copper ores, but since as much as half the original content is lost during the smelting process, Gale and Stos-Gale believe that any quantity higher than 1-2% found in a bronze artifact was an intentionally added component.[31] While some consider lead

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this method reduced the risk of spilling silver-rich molten metal along with the waste, and resulted in very distinctive "tubes" of litharge (see Conophagos 1980, Fig. 13-3a&b, and Domergue 1990, Pl XXXI.3&4).

[27] A passage from Pliny (33.95) suggests that a lead-rich mineral was sometimes used for cupellation as an alternative to metallic lead: *excoqui non potest, nisi cum plumbo nigro aut cum vena plumbi - galenam vocant - quae iuxta argenti venas plerumque reperitur* ("[Silver] cannot be smelted without using either black lead or a vein of lead called *galena* which is often found in close proximity to veins of silver.") It is presumed, however, that pure lead would have been preferred when possible, as the waste products in galena would have necessitated a higher volume of material to be effective. The direct translation of the Latin use of *galena* by the modern mineral galena has been disputed (Craddock 1995, 213-4), however, the term is never applied to refined metals.

[28] Pliny *HN* 34.159. Modern losses during this process were as low as 5% or better (Pulsifer 1888, 142; Craddock 1995, 230).

[29] Lead for cupellation also need not be desilvered in advance, since any silver it contains will be recovered during the process. Such lead can be produced at lower temperatures and thus might also have been a cheaper option than lead reclaimed from litharge.

[30] Nriagu (1983, 206-7) provides examples from Late Bronze Age to early Iron Age Egypt, Europe and Greece. Some of the studies he cites are from the early twentieth century and thus may not have taken into account the differential composition of metal alloys.

[31] Gale and Stos-Gale 1982, 216.

simply a cheap bulking agent, it also improved the castability of bronze, and thus may have been preferred by some bronze artists.

Alloys of lead and tin, commonly referred to as pewter, were also used in antiquity, with a wide variety of compositions, often ranging from 20–40 % lead, but some samples have tested as high as 80% lead.[32] Examples from Roman Britain are common, due to the abundance of tin in that region, but pewter artifacts from the Roman period have also been found at Mediterranean sites.[33] Pliny states that an alloy of two parts lead to one part tin, called *tertiarum*, was used as solder for pipes.[34] He also refers to an equal mixture of tin and lead that he calls *argentarium* which was used to counterfeit a substance called *stagnum*.[35] References to *plumbum argentarium* are often translated as 'silver lead' without further consideration. Boucher believes it must refer to tin, since certain bronze recipes call for lead (*plumbum nigrum*) and *plumbum argentarium* but not tin (*plumbum album*).[36] Rottländer, however, believes that the term refers to lead recovered from litharge after the cupellation process.[37] This lead, being "very clean, and not very inclined to oxidize in air, remains bright for a long time."[38] He thus translates *plumbum argentarium* as "bright lead" and concludes that it was given its name due to it being a byproduct of the silver industry. He suggests that tin was not mentioned in bronze recipes because it was covered under the term *aes* which can be

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[32] Tylecote 1986, Tables 28 & 29 (page 50). It should be noted that modern pewter is defined as an alloy of tin, antimony and copper, with no lead added; the term, however, is nevertheless commonly applied to ancient lead/tin alloys.

[33] In Britain, the period of greatest pewter production was the late third and early fourth centuries AD, though first and second century examples have been found (*RIB* II.1 2406). Mediterranean examples include two pewter urn cases from the Naples region (Hayes 1984, 166) and the remains of a cauldron-like vessel recovered from the second-century B.C.E. shipwreck at Kızıburun off the coast of Turkey (Deborah Carlson, pers. comm..).

[34] Plin *HN* 34.160.

[35] Plin. *HN* 34.160.

[36] Rottländer 1986, 15.

[37] Rottländer 1986, 15-16. Craddock (1995, 211) notes that lead recovered from litharge is harder and less ductile than lead smelted directly from ore. It is thus possible these different qualities were specifically sought, depending on the intended use.

[38] Rottländer 1986, 16.

translated as either copper or bronze. Neither seems to believe that it could be an alloy of lead and tin, but by Pliny's own definition this may have been the case.[39]

The interpretation of *stagnum* itself is also problematic, and may also be an alloy of lead depending on one's interpretation. Pliny states that *stagnum* is the liquid that melts first when smelting argentiferous lead, and therefore is often interpreted as an alloy of silver and lead.[40] Considering the low amounts of silver in the original ore, the metal at this stage probably contains no more than 1% silver,[41] and it is hard to imagine that all of the references to *stagnum* in the literature truly refer to such an alloy, especially considering the rarity of lead/silver artifacts from archaeological contexts.[42] Translations of the word *stagnum* tend to render it as tin, pewter, or simply leave it as *stannum*, and it may be that this term had a technical definition that was different from its popular usage.

Linguistic difficulties aside, what we do learn from Pliny's rather jumbled account is that lead was used in a great many alloys, often with specific purposes, such as solder or statue bronze, and it was frequently involved in counterfeiting or simulating more expensive metals and alloys.

EVIDENCE OF LEAD USE

Textual Evidence

Numerous references to lead come from ancient texts, from the mundane to the metaphorical, shedding light on both the types of items fashioned from lead as well as people's attitudes toward the metal. Looking at these references chronologically, we see

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[39] Rottländer's case may be supported, however, by the fact that at one point Pliny (*HN* 34.95)refers specifically to *plumbi argentarii Hispaniensis*, implying that the material comes ready-made from Spain, and so far no evidence of lead-tin ingots has been found.

[40] Plin. *HN* 34.159: "…*uius qui primus fuit in fornacibus liquor stagnum appellatur*". The *Oxford Latin Dictionary* defines *stagnum* as such an alloy with no alternate interpretations or discussion.

[41] Craddock 1995, 230. Though Forbes (1964, 228) estimates 45 to 180 oz. per ton (approximately 1.5 to 6%), these results appear to be based on modern methods and may not take into account the inefficiencies of ancient techniques. Even with 6% silver it is difficult to construe the benefits of such an alloy.

[42] A number of small nuggets of lead with up to 28% silver were found on the Porticello wreck (**9**) (Eiseman and Ridgeway 1987, 33). Due to the small denominations involved, the authors interpreted this as a form of counterfeit silver currency, but one cannot rule out the possibility that they represented a metallurgical commodity (Eiseman and Ridgeway 1987, 35-6).

a gradual increase in awareness of the metal and a broadening of applications, with most references from early Imperial Roman sources. While some of this may be a function of the types of written records kept at the time, as well as what was preserved by later generations, there is modern environmental evidence, to be discussed below, which shows that the volume of lead production increased significantly under the Romans, so its increased representation in the literature may not be coincidental. In addition to empirical data, textual references can carry with them cultural connotations and the attitudes of the writers about lead, making them an invaluable source of information about lead's status in ancient societies.

Textual references to lead in the Bronze Age are relatively rare, with lead mostly treated as a commodity and an occasional appearance as an ingredient in another material. This is not surprising since a good deal of the surviving documents from this period consist of Near Eastern palatial administrative records and private legal documents.[43] Unfortunately, to my knowledge, no systematic analysis of lead references in these documents has yet been undertaken. Due to the confusion of terms for lead and tin in Akkadian, translations of documents from this period must be surveyed carefully; many publications of early cuneiform texts identify lead where experts now believe tin was intended.[44] A reference to *mo-ri-wo-do* in a Linear B document from Knossos has been interpreted as lead based on its similarity to the later Greek word μόλυβδος.[45] This tablet may thus record a shipment of lead in the form of a raw commodity, similar to what is seen in Near Eastern sources.[46]

The Archaic period sees an increase in preserved narratives, revealing a lively use of lead in simile and metaphor. These literary devices not only prove useful in depicting some of the daily uses of lead that would not find a place in inventories, tribute lists and law suits, but also in capturing some of the contemporary attitudes about lead.

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[43] Van de Mieroop 1999, 13-22.
[44] For example, see Smith 1921, 9, 12, 14, 16, 18.
[45] Tablet Og1527, in Ventris and Chadwick (1956, 359).
[46] There has been some debate as to whether the word was correctly identified, as there was no other context to support the claim (Palmer 1963, 289) but Melchert (2008, citing Beekes 1999, 7-8) supports the identification.

The primary Greek source for this period is Homer, who specifically mentions lead only twice.[47] More references are found in the Old Testament, the date of which is much debated and widely divergent; some books may have originated in the Bronze Age, while others, some suggest, were added in the Hellenistic period. For purposes of simplification, all books here will be treated under the Archaic period, where falls the critical period of the exile of the Jews and its immediate aftermath, with the caveat that some books, the first five in particular, may be somewhat older. Most Old Testament references to lead appear in the context of metaphors of purification, with little reference to finished products of lead. Egyptian documents from this period also contain references to lead, but, as with the Bronze Age material, no systematic textual survey has been done.

The corpus of Greek texts from the Classical and Hellenistic periods provides a rich resource, allowing us to see how lead had become ingrained in the daily life of large Mediterranean city-states. The many styles of literature, including drama, oratory, philosophy, and history, reflect a wide range of applications from military to medical. Comedies in particular allow us a glimpse of lead use among the lower classes, a group poorly represented in the historical record up to this point. In these periods we also see a diversification in vocabulary, with adjectives and verbs derived from the original base noun (variously rendered μόλυβδος, μόλυβος, μόλιβος) reflecting the need to speak of lead in many circumstances, both specialized and general.[48]

The frequency of lead references increases considerably during the Roman period. The primary Roman text which treats lead in detail is Pliny's *Natural History.* Written in the mid-first century C.E., it contains two books covering all the known metals of the time, from their origins to processing and eventual use in such areas as art and medicines. Pliny provides the first surviving treatment of lead in its own right. From this work we learn much about the widespread use of lead throughout Roman society, as well as the state of Roman metallurgical technology, though interpretation of the

[47] *Il.* 11.237 and 24.80.
[48] This phenomenon had apparently already begun in the Iron Age, since Homer used the term μολυβδαίνα, a word frequently applied to lead in its function as a weight, especially for fishing. On the probable Lydian origins of the Greek word for lead, see Melchert 2008.

technical aspects of the texts is challenging and often disputed. Other ancient authors support or supplement Pliny's picture of lead use in the Roman world. Professional manuals such as those on engineering and urban water supply from Vitruvius and Frontinus give us much information about large-scale lead use, while poets such as Horace and the satirist Martial bear witness to daily use and contemporary attitudes.

Linguistic Difficulties

As evidenced by the above discussion of alloys, several considerations must be kept in mind while studying the historical record for references to lead. The first is our ability to properly interpret the ancient words for lead. A term modern scholars may interpret as meaning lead may actually have been applied to any silver-colored base metal, such as lead, tin, zinc or antimony. Much time has been spent attempting to translate the Akkadian word *anaku*, at first interpreted as lead, but now thought to be tin, although some also believe that it may have been applied to both metals under various circumstances.[49]

Even with the most basic terms in such a well-documented language as Latin, confusion easily arises. For example, Pliny states "*sequitur natura plumbi, cuius duo genera, nigrum atque candidum*,"[50] indicating that the word *plumbum* represented a single category of metal, of which there were two types, black and white (i.e. lead and tin). There are instances where the modifier (*nigrum*, *candidum*, *argentarium*) is dropped once the context is established, and *plumbum* is used on its own.[51] In such cases, the reader must pay careful attention to identify accurately the modern equivalent of the metal in question.

The question of usage leads to another difficulty involved in interpreting ancient technical terms: whether the writers committing the word to paper (or papyrus or clay) fully understood the difference between the metals themselves. Authors such as Pliny,

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[49] Landsberger 1965; Moorey (1994, 295-6) is skeptical of its interpretation as tin in relation to Middle Assyrian "cheap money," citing Powell 1990, 86-7.
[50] "Here follows [a discussion of] the nature of lead, of which there are two kinds, black and white" (Pliny *HN* 34.156).
[51] E.g., Pliny (*HN* 33.104) on antimony.

focusing on natural sciences, were cognizant of the various properties of each metal as that was, in part, the purpose of their writing. Even these writers, however, were not first-hand experts, often taking their information from older sources. Pliny, for example, is believed to have derived much of his information on lead and silver from two sources, one Greek, one Latin, leading to his introducing synonymous technical terms from both languages and possibly misinterpreting some them in the process.[52] Whether a poet, playwright, or even a scribe listing an inventory always conceived of lead and tin as distinct metals is difficult to say. In many cases it is important for the modern scholar to recognize when a certain translation is patently impossible and to consider the possibility of a related metal or alloy more appropriate to the context.[53]

Another pitfall in the interpretation of ancient texts is the tendency to use ancient references to silver as evidence for the presence or production of lead.[54] While this is not unreasonable in many cases, considering the close connection between the two metals, in fact silver does not always occur with lead. Some jarositic ores, for instance, contain silver but little or no lead, and some copper ores, a common source of silver today, contain amounts of silver recoverable by ancient technologies.[55] Likewise, lead is not always simply a by-product of silver mining, such as in Roman Britain, where the lead does not appear to have been desilvered to a significant extent.[56] Thus references to silver and lead are not interchangeable, and care must be taken in interpretation.

Lastly, one must be wary in evaluating the historical depth of a reference – some ancient authors attribute certain technologies or applications to earlier periods. In some cases, the writer may be perfectly correct, in others simply transmitting folk knowledge

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[52] Healy 1999, 57-8.
[53] Forbes 1964, 200. For further discussion of the difficulties encountered in pre-Roman languages, see Nriagu 1983, 1-4, and Forbes 1964, 200-201.
[54] Nriagu (1983) does this frequently. Moorey (1994, 293) also does this when he proposes the circulation of lead along with silver over Bronze Age caravan routes.
[55] Tylecote (1992, 71) points out that in cases where jarositic ores were exploited, lead may have been imported in order to extract the silver via cupellation. Butcher and Ponting (2005, 192-194), examining Roman *denarii* of the 1st c. C.E. using both chemical and lead isotope analysis, have identified several coins derived from the jarositic ores of the Rio Tinto mines in Spain, which appear to have been processed using lead brought in from Cartagena and Britain.
[56] Tylecote 1986, 70.

with no basis in fact.[57] This can also apply in the other direction, such as when a location has a reputation for a certain type of production or artifact that may no longer exist in that area. A writer attributing an oft-used epithet or image may be reproducing cultural imagery with no connection to the state of things in his own time period. A relevant example is the Late Roman descriptions of Spain as being rich in gold long after the gold mines there had been abandoned.[58] In this area, archaeology has proved a significant help in providing a more accurate temporal framework for the development of lead technology and use.

Archaeological Evidence

If one depends only on literary references for knowledge of ancient lead, one would most likely grossly underestimate the extent of its use. Lead artifacts have been found at sites from all across the ancient world and dating as far back as the late Neolithic (ca. 6500 – 4500 B.C.E.), well before the advent of written language. To attempt to produce a full accounting of the finds of lead in the archaeological record is beyond the scope of this work and would most likely prove impossible. Examples representative of nearly all of the uses attested in the literature have been found in archaeological contexts, often from an earlier period than the first textual attestation. In addition, other uses have been attested archaeologically that ancient authors rarely, if ever, bothered to discuss.

Some problems with lead in archaeological contexts must be kept in mind. Due to its extreme malleability, many finds, especially in land sites, have been deformed beyond any recognizable shape. It can be difficult to determine whether such items represent ancient scrap lead, abandoned in a twisted state, or if they lost their original shape as a result of postdepositional factors. Many such finds do not make it into published site reports, especially in favor of more diagnostic material such as pottery, thus making it difficult for scholars to evaluate the level of lead use at a site.

[57] There is also the possibility that changes have crept into manuscripts over centuries of copying, which reflect anachronisms introduced by the copyist.
[58] Domergue 1990, 215.

Even when identifiable, lead objects can be so common that they are left out of publications in favor of more historically or artistically significant items.[59] Figurines and other forms of lead sculpture are not overlooked, but are rare and do not represent average lead use.[60] As a result, the most commonly published lead finds are those which contain writing, thus being valued for their epigraphical significance rather than their physical makeup. Therefore, based on archaeological reports, items such as ingots, letters, *defixiones* and *tesserae* may appear to constitute a higher percentage of ancient lead consumption than was actually the case.

USES OF LEAD

Lead use in the ancient Near East and Mediterranean was widespread and varied, The earliest uses appear in Anatolia and the Cyclades, with penetration into Near Eastern and Egyptian contexts by the Early Bronze Age. There appears to be an overall lull in its use during the Middle Bronze Age, followed by a resurgence in the Late Bronze Age, with the noticeable addition of mainland Greece as a dominant area of production.[61] This region continues to play an important role in the intensification of lead use throughout the Archaic and Classical periods, though use increases throughout the Mediterranean coastal regions. The Hellenistic and Roman periods show increasing dependence on lead primarily in urban and military settings, with little effect on rural agricultural life.

Categories of Use

I have divided the types of use into categories that reflect the probable demand placed on the lead supply based on quantity and frequency of use: Domestic, Professional, Military, and Infrastructural. While it is impossible to determine exactly what percentage of lead consumption was tied to each use, this method of categorization

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[59] For example, references to items such as lead needles and wires are generally only cited in a large site publication with a complete catalog (e.g. Soles and Stos-Gale 1994, 52), but otherwise go unremarked.
[60] Important examples, discussed further below, include the cache of lead figurines at the Temple of Artemis Orthia (Wace 1929), the lead figurine from Knossos (Hatzaki 2005, 189-90) and the temple models from the Comacchio wreck (**39**) (Berti 1990, cat. nos. 133-138).
[61] Stos-Gale and Gale (1982, 472-3) summarize the evidence for lead use patterns in the Bronze Age Aegean.

allows one to better consider what forces were driving the investment in lead production and distribution.

Domestic uses are any application employed by individuals, in daily life, and generally include either occasional or regular use, but in low quantities. These cases have little economic pull individually but, as a group, represent a constant demand that may have been satisfied to some extent from an open market, though recycled scrap metal likely provided a substantial portion of the supply.

Professional applications represent high frequency use in larger quantities by specialists in a field that is not necessarily lead-based but requires either lead ingredients or products for successful practice; for the ancient world, these were primarily architects, medical practitioners, mariners, and bronze artisans. These people would have needed steady access to supplies, and, depending on the quantity they consumed, most likely had frequent recourse to an open market but, for large enough operations, may also have had connections to networked markets.

Military uses are limited both temporally and geographically to areas of current combat and occupation. As such, they represent a mobile demand that would have affected supply routes and often placed demand on local sources as soon as reliable extraction facilities could be controlled or established, if local ones were not already in place. Military applications for lead were few compared with the need for iron or bronze, though certain professional and infrastructural applications would also have been present in military establishments. Thus shipments of processed lead may have been brought in to satisfy all these demands, though recycling was certainly an option. Whether these shipments were supplied directly from state-controlled sources, or whether state funds were supplied to acquire lead from an open or networked market is not easy to determine.

Another realm of primarily government use, deemed infrastructural, is the maintenance of public needs and facilities, the most visible of which were the water supply and public bathhouses of the Roman world. These represent high-volume though intermittent demand, yet constant maintenance and repair may have resulted in a regular, though moderate demand for new material in developed, urban areas. The less visible demands of state mints dating back to the advent of currency in the sixth century B.C.E., may have spurred a high-volume demand that required steady access to large quantities of metal. In many cases, infrastructural demands would have been filled from state-controlled supplies, but there could also have been cases, such as when private citizens donated public-works projects or when contractors were engaged by the government, where materials were acquired through networked or open markets.

Domestic Applications

The category of domestic use represents any individual, private use of lead regardless of social class. As such, it is not limited strictly to use in the home, but encompasses decorative, religious, and utilitarian uses. The user is not necessarily the producer of the item, and, as such, further consideration will be given to the artisan in the section on professional uses. Domestic uses are not common in the historical record, but have been revealed archaeologically over many decades of excavation. Many of these uses were most likely based on opportunistic reclamation of scrap metal, but may involve some use of fresh supplies of metal.

The oldest known use of lead is for decorative items, which include beads from sixth-millennium B.C.E. layers of Çatalhöyük, Turkey, and a bracelet from fifth-millennium levels at Yarım Tepe I, Iraq.[62] At both sites, these artifacts were found in association with copper items, but since copper occurs as a native metal and lead rarely does,[63] it is believed that these finds suggest that lead may have been the first deliberately smelted metal in history.[64] The frequency of lead finds, however, remains

[62] Mellaart 1967, 117; Moorey 1994, 294; see also Wertime (1973, Table 1) for a chart of lead and copper finds from this period (courtesy of J.K. Bjorkman). Some now claim the Çatalhöyük beads were made from galena rather than processed metal (Moorey 1994, 294), but there is no doubt over the Yarım Tepe lead bracelet.

[63] The term *native metal* refers to a metal found naturally occurring in its pure metallic state rather than combined with other elements in a mineral state. Such metals require no complex processing to remove impurities, and can be hammered into shape with relative ease. Gold is commonly found this way, and it is not unusual for silver and copper to occur in this state, though not in large quantities. In geographical discussions, when referring to metals derived from a certain locality, the term *indigenous* will be used.

[64] Nriagu 1983, 67; Heskel 1983, 362.

relatively small in comparison to copper and copper-alloy artifacts from the end of the Neolithic through most of the Bronze Age. This no doubt reflects the difficulty of finding useful applications for lead, but may also be affected by reporting bias. Lead's lack of a bright, reflective surface made it rare as a decorative medium, especially after the spread of silver metallurgy in the fifth millennium B.C.E.

Artistic applications of lead were, however, not uncommon in the ancient world, though not widely published today.[65] When first in use, it is possible lead was considered a prestigious material, but by the Late Bronze Age it was a medium more suited for disposable purposes, such as votive offerings, and, perhaps, to decorate the homes of the lower classes who could not afford items of bronze or precious metals, though there is little archaeological evidence for such use. Several small but finely detailed lead models of temples discovered on the Comacchio shipwreck (**39**) from the Roman period are an extremely rare example of fine art in lead and show that even in later antiquity, pure lead could occasionally be used for prestige items.[66]

The votive aspect of lead figurines and miniature representations is the most commonly attested. Three lead boat models in the Ashmolean Museum are believed to come from a grave on the Cycladic island of Naxos and date back to the third millennium B.C.E.[67] The few textual references to lead figurines in Assyrian texts are usually in reference to a temple dedication.[68] New Kingdom Egyptian documents hint, too, at the use of lead for statuary, also in a religious setting.[69] A collection of lead figurines was found in the Temple aux Obélisques at Byblos,[70] though the majority of figurines found at this site were bronze. Evans reported a lead Snake Goddess figurine from Middle Minoan contexts at Knossos.[71] A cache of over 100,000 lead figurines

[65] Archaeological instances of lead figurines and statuary have been summarized by Nriagu (1983, 254-5), with most examples coming from late 19th and early 20th-century excavations.
[66] Berti 1990, 70-2.
[67] Renfrew 1967, 18.
[68] Moorey 1994, 295.
[69] A list of offerings of Ramses III in the Papyrus Harris I (Breasted 1906, IV §302) includes a statue of a Nile god in lead.
[70] Dunand 1954, Pl. 129. Negbi and Moskowitz (1966, 24-6) suggest these were buried in the late 18th century B.C.E.
[71] Hatzaki 2005, 189-90.

spanning ca. 800-250 B.C.E. have been recovered from the Sanctuary of Artemis Orthia in Sparta, and other sanctuary sites from Sparta have produced similar figurines.[72] While some have remarked on the unusual predominance of lead figurines at Sparta, the use of lead as a votive medium is not limited to this region. Nearly 300 lead and bronze figurines were recovered from the Cabiri Sanctuary at Thebes dating from the tenth to fifth centuries B.C.E.[73] Miniature anchors have been found at temples ranging from the Black Sea to the Temple of Vesta in Rome, starting perhaps as early as the fifth century B.C.E. and persisting as late as the ninth century C.E.[74] Phallus amulets were worn as common apotropaic devices in the Roman world, especially amongst soldiers; lead examples have been found at sites in Roman Britain and Germany.[75]

Another widespread ritual-based use of lead was for *defixiones.* These were small, thin sheets of lead or lead alloy on which a person's name was written, sometimes along with a detailed curse, then frequently pierced, folded and/or rolled, and deposited in a grave, sanctuary or water source.[76] These are rarely attested historically, though Tacitus, in writing on the death of Germanicus, reports that a search of the dead man's room turned up many forms of curses, including a lead tablet inscribed with the name Germanicus.[77] Over 1600 examples, however, are known archaeologically, with the majority in Greek, but at least 500 are in Latin.[78] The oldest yet found date to the fifth or sixth century B.C.E., and are derived from the Sicilian Greek colony of Selinus, but the

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[72] Wace 1929, 250-2, whose data from Artemis Orthia are presented with a revised chronology in Whitley 2001, 311.
[73] Krysko (1979, 110), citing a personal communication with B. Schmaltz of the Deutsches Archäologisches Institut Athen.
[74] Shapovalov 1994, 264-66; Gianfrotta 1977, 286. Since casting lead did not require a specialist and many ships carried lead for hull repairs, discussed further below (p. 30), sailors may have produced their own dedicatory pieces, rather than purchasing them from an artisan, resulting in a higher incidence of maritime-related votive offerings.
[75] Johns and Wise 2003, 275-76; Durali-Mueller *et al.* 2007, 1557, who also report other "sacrificial" lead objects such as roundels (wheel-shaped votive objects), ribbons and plates.
[76] Figurines inside miniature coffins have also been found, with a name or curse inscribed on the body or the coffin lid (Gager 1992, 15-8). Gager (1992, 18) also points out that love spells were often placed in the recipient's home, and those relating to horse or chariot races were placed in the stadium, often near the starting gates.
[77] Tac. *Ann.* 2.69.
[78] Ogden 1999, 3-4.

majority of examples prior to the Roman Empire are from Attica.[79] The relative permanence of lead inscriptions, due to the metal's resistance to corrosion, possibly combined with its noxious potential, made lead the ideal medium for such curses.[80] Its weight may also have played a factor, giving the impression that the curse will readily sink down to the underworld. In some cases, the medium of lead is integral to the curse, such as one from the fourth century B.C.E. which wishes for the victim's tongue to become like lead.[81] Chemical analysis of a cache of curse tablets from Roman Bath indicates they were primarily made of lead and tin in a wide variety of ratios, indicating heavy use of recycled and scrap metals.[82] Based on the length of some inscriptions and the consistency of the formulae used, there is some evidence that, at least in the Roman Imperial period, there may have been professional scribes who wrote curses for clients, and may have kept a supply of blank lead sheets on hand.[83]

The connection between lead and witchcraft appears to have been relatively common, but it is rarely spoken of in literature. Ovid makes a brief reference to binding threads together with lead as part of a ritual for the goddess Tacita.[84] The same poet, in telling the story of Apollo and Daphne, reports that Cupid struck the former with an arrow of gold, which caused love, and the latter with one of lead, which repelled love, thus relegating lead to the role of pernicious agent, a common literary role for lead.[85] It is difficult to assess the amount of use related to these types of spell ingredients, as such items rarely survive archaeologically or may not be identifiable as related to magic. Volumetrically, lead use in witchcraft was likely primarily represented by *defixiones*.

Lead as a writing medium, primarily through the use of sheets of lead as a form of stationery, dates back at least to the Bronze Age, although it is first discussed in

[79] Ogden 1999, 4.
[80] Ogden (1999, 10-11) points out that other materials were used for curses, such as bronze, copper, ostraka, limestone, papyrus and wax, but lead makes up the majority of examples.
[81] DTA no. 67 cited in Ogden 1999, 12, who also cites several examples of curse tablets made from lead taken from a cold-water pipe.
[82] Ogden 1999, 11, 13.
[83] Gager 1992, 4-5.
[84] Ov. *Fast.* 2.575.
[85] Ov. *Met.* 1.466-471. This dichotomy between base and noble metals is echoed in the realm of *defixiones*, where surviving inscribed silver and gold tablets are always inscribed with words of protection rather than curses (Ogden 1999, 11).

literature in the Roman period. Pliny, citing Marcus Varro, claims that before Alexander the Great brought papyrus from Egypt, people used a variety of writing surfaces, including tree bark, wax tablets, and folded sheets of lead, suggesting an early advent of this practice, which had mostly petered out by the Roman period.[86] The discovery of thin lead sheets containing Hittite hieroglyphics from a third-millennium B.C.E. Assur site supports an early date for this practice.[87] Several inscribed lead tablets from building foundations have been found in Late Bronze Age contexts in Mesopotamia.[88] Such uses may also have a connection with the magical properties associated with lead. Many examples of personal correspondence on lead as well as accounting records have been found from the Archaic, Classical, and Hellenistic periods.[89] In the second century C.E., Pausanias reports seeing, in Boeotia, a lead tablet upon which the works of Hesiod were inscribed, though how old it was at that point is unknown.[90] The practice was apparently not entirely forgotten in the Roman period and still proved useful on occasion. Frontinus even reports a military stratagem of soldiers carrying secret messages inscribed on lead out of the besieged city of Mutina by fastening them to their arms and swimming across the river.[91] The combined advantages of softness and imperviousness to water made lead a useful medium for writing, especially for letters consigned to water-borne transport.

Other writing-related applications for lead have also been attested. Job offers the somewhat cryptic "O that with an iron pen and with lead they were engraved on a rock for ever!"[92] There has been difficulty in interpreting the role of lead in this process, though it could be a very early reference to the technique of carving letters in stone and filling them with lead, an example of which dating to the Middle Ages survives at the

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[86] Plin. *HN* 13.21.
[87] Krysko 1979, 54.
[88] Nriagu 1983, 245-6.
[89] Examples of personal letters have been presented by Vinogradov (1998). Wilson (1998) focuses on 11 Archaic documents from the Black Sea, Emporion, Pech-Maho and Corcyra. Jordan (2000) compiled a total of 9 published letters, some of which were included in Wilson's list. Kroll (1977) presents a collection of records concerning horses belonging to members of the Athenian cavalry found in a well at the Athenian Agora.
[90] Paus. 9.31.4-5.
[91] Frontin. *Str.* 3.13.7.
[92] 19:23-24.

Cathedral in Cologne.[93] Regardless of its technical interpretation, the passage shows a relationship between lead and writing. Pliny notes that lead, bronze and silver may all be used to make black lines, implying this is a drawback; however, it is clear from other authors that this property of lead was harnessed regularly for ruling lines to guide the pen.[94]

Another very early use of lead was as staples or clamps for repairing damaged pottery vessels. Examples of such repairs from the Cycladic Islands have been dated as far back as the Early Helladic period,[95] and examples continue to turn up from many periods and locations in the ancient world. This is another common practice that was rarely attested in literature. Indeed the earliest appears to be Cato in the second century B.C.E. who, while making suggestions for activities to pursue around the farm during bad weather, lists repairing broken pottery with lead clamps.[96] This provides a contrast with the larger scale applications generally perceived to be in the hands of specialists.

Another farm-based application of lead was as a vessel for boiling wine and dyes, and for collecting oil from an olive press. Such vessels are little attested archaeologically, but are specified by Cato, Columella, and Pliny.[97] Lead cooking vessels and other kitchenware, which may represent types also used on land, have been discovered on shipwrecks of the Roman period, though may have been more common aboard ships, where ceramic vessels were prone to breakage.[98] All this evidence dates from the Roman period, and it may be that the high availability of lead during this period led to its use in this arena. As with pottery repairs, however, the use of lead vessels may be an older practice that appears relatively late in the historical record. A brief mention

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[93] Krysko 1979, 66. Lo Schiavo and Boninu (1985, 141) also mention a large dolium with the letters L F P in lead.
[94] Plin. *HN* 33.60-1. For examples of lead-ruled lines, see Catullus (22.8) and Julianus of Egypt (*Anth. Pal.* 6.67-68), who described a lead disc which was run along the edge of a ruler.
[95] Renfrew 1967, 4.
[96] Cato *De. Agr.* 39.1.
[97] Cato *De. Agr.*. 66.1 (for collecting olive oil); 105, 107, 122 (for wine); Columella *Rust*. 12.19-20 (for wine); Plin. *NH* 9.133 (on preparing purple dye). Vitruvius also prescribes placing a bronze or lead vessel in a hole at sunset as means of finding water (*De Arch.* 8.1.4.)
[98] Rosen and Galili 2007, 301.

in Zachariah of a basket with a leaden cover suggests a further rural domestic application that may have been too common to find a place in literature. [99]

Cosmetics were a common personal application for lead compounds. The kohl eye makeup, so popular among the Egyptians and dating well back into the Predynastic period, was frequently derived from the lead-rich mineral galena.[100] The raw mineral was usually crushed into a powder or paste for use but was never processed into metallic lead. A lead-based white foundation for ladies' faces was in use at least by the 4th century B.C.E., when Xenophon writes of a husband asking his wife not to resort to such deceitful arts.[101] This lead carbonate compound, today called white lead or ceruse, occurs in nature only in limited amounts, but by the Hellenistic period, if not earlier, it was being produced by chemically altering metallic lead, the process being described as early as the third century B.C.E. by Theophrastus.[102] Due to the complexity of this process, it is likely that it was usually purchased ready-made by domestic consumers. As this compound also had several professional applications, there appear to have been manufacturers specializing in its production, and therefore the topic will be treated further in the professional section. There is some evidence that use of lead in cosmetics gave way to other natural minerals such as gypsum and calcite in the Roman period.[103]

Other domestic uses, primarily attested in the Roman period, include funerary urns, and in the Christian era, sarcophagi. Such sarcophagi were often decorated with a variety of motifs and scenes cast into lead sheets which were soldered together[104]. Rarer uses mentioned in literature include the rather ingenious application of a funnel attached to a leather hose to gather fresh water from a spring at the bottom of a salt-water channel,[105] exercise weights,[106] and Livy describes two stone chests lined with lead.[107]

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[99] Zach. 5, 7-8.
[100] Lucas (1962, 80-2) reported that of 74 samples of Egyptian cosmetics, 45, or 60%, were galena.
[101] Xen. *Oec.* 10.7.
[102] Theophr. *De Lap.* 56-7. In the Roman period, Vitruvius (*De Arch.* 8.3.18) and Pliny (*HN* 34.175) also describe various processes for producing ceruse from metallic lead.
[103] Welcomme et al. 2006.
[104] Krysko 1979, 110-111, and Figs. 107-113. The motifs were likely applied with stamps to a sand mold, allowing multiple uses of the same figures and designs in one mold, similar to the production of terra sigillata (Alexander 1932).
[105] Strabo 16.2.13.

Professional Applications

Several ancient professions involved the use of lead objects or raw lead in the performance of duties. Most of these involved the regular replacement or replenishment of supplies, requiring a reliable supplier or set of supply lines. The volume required varies, so some professions affected demand more than others. Many lead-consuming professions were practiced in nearly every ancient town, while others were geographically restricted, such as to coastal regions for fishermen. This would influence the amount of lead coming into certain regions, possibly leading to increased access to lead in those regions for other uses, such as domestic.

Fishing

Perhaps the oldest known professional use of lead is for fishing weights either for individual lines or as sinkers for nets. While the oldest known sinkers are of stone, lead seems to have been used as early as the Bronze Age, at least in the eastern Mediterranean.[108] One of only two references to lead in Homer refers to fishing.[109] While the poems of Homer are generally dated to the eighth century B.C.E. or later, the oral tradition from which they originated may go back to the end of the Bronze Age, implying an early date for the use of lead by fishermen. An oblique reference to the pastime can be also found in the Old Testament. In Exodus, one of the oldest books of the Judeo-Christian tradition, with its roots, like Homer's, in the Bronze Age, the destruction of the Pharaoh and his chariots in the Red Sea is likened to the sinking of lead.[110] Even though this is not an explicit reference to fishing, it is the most likely purpose behind dropping lead into water.

The relative persistence of form of fishing line weights through time makes them difficult to date when found archaeologically. Since they can easily intrude on shipwreck

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[106] Lucian (*Lexiphanes* 5); Quintilian (*Inst.* 11.2.24); and Suet. (*Ner.* 20.1) who reports that the singer Terpnus trained his voice by, among other things, lying on his back with lead plates on his chest.
[107] Livy 40.29.3.
[108] Galili et al. 2002, 195.
[109] Hom. *Il.* 24.80.
[110] *Ex.* 15:10

sites from later fishermen, one must depend on securely associated artifacts for reliable dating. Securely-associated weights were found on both the Cape Gelidonya and Uluburun shipwrecks, dating from the Late Bronze Age.[111] By the Roman period one sees decorative motifs on weights, and a few examples of molds have been found at underwater sites, suggesting that some fishermen cast their own weights as needed and carried supplies of lead with them on board.[112] Since sinkers were easily lost during fishing, it was necessary for fishermen to replace them frequently, necessitating a relatively low-volume but steady demand for lead.

Merchants

Another professional class of artifact also attested beginning in the Bronze Age was the pan-balance weight. These were vital tools for merchant traders on land and sea, and their presence on ships and in coastal cities was common. Weights usually came in sets adjusted toward a regional weight standard, and merchants are believed to have carried their own set, or even several sets depending on the regions with which they conducted business.[113] In the Bronze Age Near East and Egypt, such weights were usually made of stone or bronze, both being relatively stable and resistant to damage.[114] Some bronze and stone weights, however, had lead cores or plugs, which would allow both for smaller volume per weight, as well as the ability to easily adjust the weight if necessary.[115] While pure lead balance weights were rare in the Near East, examples from Greek sites such as Ayia Irini, Akrotiri, and Knossos attest to their common use in the

[111] Net weights from the Cape Gelidonya wreck were reduced almost entirely to a lead carbonate and were identified as weights primarily by shape (Bass 1967, 41). The Uluburun site yielded over one thousand well preserved net weights, isotopic analysis of which has shown significant mixing of metals from different sources suggesting opportunistic acquisition of lead along coastal routes (Cemal Pulak, pers. comm.).

[112] Galili et al. (2002, 195) report several mold finds from the coast sites of Kastra and Shiqmona, both with a Byzantine date; as well as a spoon apparently used for pouring or casting lead from the 7th C.E. century wreck at Yassi Ada (Kuniholm 1982, 298), so the practice of casting on board may be a late innovation.

[113] Pulak 2000a, 264.

[114] Pulak 1996, 4-6.

[115] The Uluburun assemblage of 149 weights included five haematite and three bronze sphenoid weights with lead plugs and nine zoomorphic bronze weights with lead cores (Pulak 2000, 254-256).

Aegean, primarily on Crete and the Cycladic Islands.[116] Lead continued to be used for balance weights in later periods, though not exclusively. Graeco-Roman examples of metal balance weights were cataloged by Petrie, and of all the eight standards he identified, only the Attic stater was represented primarily by lead examples; elsewhere bronze was the more common metal used.[117] Such items would not have needed replacement as frequently as fishing weights, and probably represented a valued tool or even a prestige item for merchants.[118] Despite its prevalence in the Aegean, the use of lead does not reflect, overall, a large volume of consumption. Of the 149 weights discovered on the Bronze Age shipwreck at Uluburun, only eight were of lead, along with 9 zoomorphic weights filled with lead, for a total combined weight of only 3.84 kg.[119]

Mariners

While the previous applications are both attested aboard ancient shipwrecks, it is not until the late Archaic period that we being to see use of lead for the maintenance and functioning of the ship itself.[120] Underrepresented in literary sources, archeological evidence, primarily from shipwrecks, has revealed a wide variety of shipboard applications, some requiring more lead than others, but altogether possibly representing the most volumetrically significant professional use of lead.

Earliest, and perhaps most important, was the application of lead to anchor design. While stone anchors prevailed in the Bronze Age, use of wooden anchors with stocks of a heavier material began to replace them in the Archaic period. Stone stocks

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[116] Petruso 1992, 64-5.
[117] Petrie 1974, pl. XLIII – XLVI. Percentages of lead weights per standard are,: Peyem - 8%; Daric – 13%; Stater - 93%; Qedet - 8%; Necef - 6%; Khoirine – 15%; Beqa – 36%; Sela – 42% ; Ungia – 8%. As many of these were acquired through the antiquities market, there may have been a certain bias on the part of both the collectors and the dealers in favor of higher value metals.
[118] The existence of bronze zoomorphic and anthropomorphic sets (e.g. Lassen 2000, Fig. 16.1; Pulak 2000, Fig. 17.3) show the artistic investment that could be made in these items.
[119] Pulak 1996, Tables 4 & 5.
[120] Based on the lack of ship-related lead artifacts on the Uluburun and Cape Gelidonya Bronze Age wrecks, it appears such uses were a later innovation; however, the dearth of Iron Age wrecks makes it difficult do assess whether some applications actually developed in the Iron Age rather than the Archaic period.

were used as early as the seventh century B.C.E., but they were then supplanted by wooden stocks filled with lead, a Haldane Type II anchor stock.[121] The earliest lead-cored anchor stock may come from the Bon Porté 1 wreck, east of Marseille, dated to the second half of the sixth century B.C.E., though this identification is somewhat tenuous.[122] The 14 lead cores discovered in the Tektaş Burnu wreck off the coast of Turkey leave little doubt that the transition to this type of anchor was well under way by the mid-fifth century B.C.E.[123] This style continued into the second century B.C.E., at which point it began to be replaced by Type III anchors with stocks consisting of a single cast piece of lead as well as lead collars to support the arms.[124]

Lead anchor stock cores vary widely in weight, depending on the size of the anchor, usually with two to four per anchor.[125] Weight for Type III lead stocks also varied considerably, and as most ships carried multiple anchors, anywhere from 100 to 2,000 kg of lead could be devoted to this use on a single sea-going merchant vessel. For example, five lead anchor stocks are associated with the second century B.C.E. Mahdia shipwreck, two of which weighed in at 628 and 695 kg, though this appears to be an unusual case.[126] A more likely example of an average anchor complement from the same

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[121] Haldane 1984, 5-7. Haldane designates stone anchor stocks as Type I, wooden stocks with lead cores as Type II, and cast lead stocks as Types III and IV. The shank and arms of such anchors were of wood, sometimes with bronze or iron fluke points at the tips of the arms (Haldane 1984, 19 and n. 81).

[122] Joncheray (1976, 22) published the piece as an ingot but suggests it may also really be part of an anchor stock. Haldane (1984, 7 and note 31) considers the piece only tentatively identified as a core, since its shape is inconsistent with others from the same type of anchor (Type IIA). Trethewey (2003, 113) believes it was an ingot due to the lack of notches or casting bolts generally found on later anchor stock cores that helped secure them within the wooden stock. Joncheray (1976, 22), however, identified the possible impression of a wooden mold on one side of the piece. Only one other case of lead ingots cast in wooden molds has so far been identified from the Comacchio shipwreck of the first century B.C.E. (Domergue et al. 2006, 15); the rarity of the occurrence in contrast to the common procedure of pouring lead cores directly into the wooden stocks leads me to conclude the Bon Porté piece is a core. Also, if an ingot, it would be the earliest truncopyramidal lead ingot yet recovered, predating the Roman Republican examples by several centuries. It may be that this was an early attempt at using lead in an anchor, and the more sophisticated forms developed later through trial and error.

[123] Carlson 2003, 595. A pair of lead anchor stock cores were also found in the Phagrou wreck, dated to ca. 450 B.C.E. (Kazianes 1996, 724).

[124] Haldane 1984, 12-3.

[125] The Tektaş Burnu wreck had 5 anchors with a total of 14 lead stock cores, ranging weight from 2 to 17 kg, for a total of 135.5 kg (Van Duivenvoorde, in press). The Porticello wreck (**9**) yielded four stock cores, weighing from 74 to 123.5 kg, for a total of 413.5 kg (Eiseman and Ridgeway 1987, 19).

[126] Merlin 1912, 392. Gelsdorf (1994, 86) estimates the total weight of all five anchors (including their wooden components) to have been approximately 13 metric tons.

time period is the Chrétienne C wreck, which carried at least three anchors, with stocks weighing 104, 84 and 66 kg.[127] Isolated anchor stocks are often found on the sea floor, attesting to a relatively high loss rate for these items, thus frequent replacement likely increased the demand for lead in this sphere.[128]

While the solid stocks appear to have been cast entirely from lead, though not necessarily from supplies fresh from the mines, some earlier stock cores show more ad hoc production. An isolated core found off the coast of Turkey consisted of four lead ingots apparently jammed whole into one half of a wooden stock and then secured by pouring molten lead over them.[129] This suggests that there was a more specialized production of lead type III anchor stocks for the maritime market,[130] while some lead cores were probably made on a more informal basis, either in port facilities or shipyards or even by the sailors themselves as needed.

Another volumetrically significant use of lead on ships was for sheathing the hull. This process involved fastening thin sheets of lead, usually no more than 1-2 mm thick, with copper tacks to the outer planking of the hull up to and even above the waterline. The total weight of lead required to sheath a complete hull varies greatly depending on the hull shape and the thickness of the lead, but was likely in the range of 500 to 1000 kg for a moderate merchant vessel in the 14- to 18-m range.[131] For a large cargo ship, such as the Grand Congloué, which is estimated at 40 m, sheathing might have weighed in the range of 4 or 5 tons.[132]

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[127] Joncheray 1975, 107.
[128] The description of Paul's disaster at sea (*Acts* 27:29) bears witness to the conditions under which many of these anchors were lost, stating that during a particularly bad storm four anchors were cast from the stern to prevent the ship from running aground. These anchors presumably were dragged behind them in the manner of a storm anchor, but their recovery was not guaranteed; many must have snagged and been lost on rocky shorelines.
[129] Pulak 2008, pers. comm. This may represent an emergency shipboard repair after the loss of the original core.
[130] The appearance of cast decorations on many lead stocks, such as those in Carrazé 1974, also supports a more standardized production process for this type of anchor.
[131] Calculations are based on rough estimates of hull surface area to the waterline and a sheet thickness of 1 mm.
[132] An early estimate was given as 20 tons (Swiny and Katzev 1973, 357), but this appears excessive given the reconstructed dimensions of the vessel.

This process was not applied to every ship, and while many believe its purpose was to protect the wooden hull from marine borers, it has been convincingly shown that its primary purpose was to prevent leakage.[133] Not addressed in the historical record until Athenaeus' second-century C.E. description of the Hellenistic forty-banked ship of Ptolemy Philopator, the earliest archaeological attestation of lead applied to a hull comes from the early fourth century B.C.E. wreck at Porticello (**9**).[134] In this case, the lead appears to have been applied in discrete patches, perhaps as repairs, and did not cover the entire hull. Complete hull sheathing is not attested until the early third century B.C.E. Kyrenia wreck.[135] In addition to sheathing on the hull itself, two spare rolls of lead sheet were found on board, presumably to make repairs to the sheathing as needed.[136]

As with anchors, and unlike many other lead-derived objects, lead sheathing appears to have been common only in the Hellenistic and Roman Republican periods, tapering off by the late first century C.E., although examples have been attested through the fourth century C.E.[137] Hocker suggests this decline was related to a need to reduce labor-related costs,[138] but there may also have been issues related to access to lead supplies, as lead mining began shifting from Spain to Britain in the mid-first century C.E.

Another shipboard application of lead is its us as sounding weights, an important navigational tool. Used to test the depth and quality of the seabed, these were generally bell-shaped, with a hollow cavity inside the bell filled with tallow to collect a sample of the seabed. While several stone examples have been found, the working of stone into

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[133] Hocker 1995, 199-200. The common suggestion that lead's toxicity was effective at deterring toredo worm or other encrustation (e.g. Nriagu 1983, 256-7) does not appear to be xsupported by any scientific evidence.
[134] Ath. 2:421–425; Eiseman and Ridgway 1987, 16; for the most recent dating of the wreck see Lawall (1998).
[135] Steffy 1985, 77.
[136] Katzev 1969, 58. This is a rare archaeological example of lead sheet as prefabricated commodity; several hundred years later, Pliny (*HN* 34.164) identifies pipes and sheet (*lamna*) as the most common uses for lead.
[137] The latest example is the Sobra wreck, tentatively dated to 320-340 C.E. (Parker 1992a, 408). See Fitzgerald (1995, 184-8) for a catalog of ancient wrecks with lead sheathing.
[138] Hocker 1995, 202-3.

such a shape would have been very time consuming, and at least one examples in lead has been found dating to the early fifth century B.C.E.[139] Averaging 5–7 kg in weight, they were not especially large, but like fishing weights, were easily lost, and so frequently replaced.[140] As with anchors, more than one were likely carried on board at a time in case of loss.[141] Their relatively unique shape may have given rise to a certain amount of specialized production for the maritime market.

On sailing ships, brailing rings, used to guide ropes used to trim the sails, were sometimes made of lead. While evidence for brailed sails dates as far back as the Egyptian New Kingdom,[142] the earliest securely-dated find of lead brailing rings is from the early sixth century B.C.E wreck at Giglio (**6**).[143] The discovery of over 170 rings on the Kyrenia shipwreck, suggesting the presence of a spare sail in the hold, attests to how many rings may have been required by an individual sail.[144] Rosen and Galili suggest that since lead rings were "heavy, yet 'softer' than iron or bronze rings, [they] minimized wear on rope and sails."[145] Despite such advantages, lead was not always the material of choice for brailing rings. For example, of the 169 brailing rings recovered from late-first century B.C.E. through mid-third century C.E. contexts in the Red Sea port of Myos Hormos, 118 were made from cattle horn, and 51 from wood.[146] These were primarily recovered from trash deposits, thus the lack of lead examples could be explained by recycling, or it may be that lead was a rare commodity in the remote port and not readily available; on the other hand, the weight of the lead rings may have been detrimental to the sail and thus may have been used only when other options were not

[139] Cited by Oleson (2000, 305), this weight comes from the archaic wreck at Gela (Panvini 2001, 63, cat. no. 36284).
[140] In the 43 sounding weights analyzed for weight by Oleson (2000, 308-9) found a mean of 5.5 kg and an average of 7.4 kg, the latter figure being skewed somewhat by three exceptionally heavy specimens (from 16.9–19.0 kg). See also Galili et al. (2009), whose typology of sounding weights from the Isreali coast includes 63 examples, the heaviest of which is 20.6 kg.
[141] Oleson (2000, 308) notes that only six wrecks have so far been found with multiple sounding weights on board, and in most cases they were in pairs. The majority of examples are isolated finds not associated with wrecks.
[142] Casson 1971, 37.
[143] Bound 1991, 27 and Fig. 60.
[144] Whitewright 2007, 288.
[145] Rosen and Galili 2007, 306.
[146] Whitewright 2007, 283, 285.

available or for heavier-duty sails.[147] Other, larger lead rings found from underwater sites may have been used as part of antifouling devices for nets or anchors, such as on the Porticello wreck (**9**).[148] As with sounding weights, a ship most likely carried several of these rings in case of loss.

On oared ships, lead weights could be used to help balance the rowing oars as well as the steering oar.[149] Some of those found are inscribed, indicating that they may have been considered personal property of the rower, but whether the initial lead was provided from ship stores or by the individual is not clear.[150] This practice is also attested in Athenaeus' description of Ptolemy Philopator's ship.[151]

Lead was also used for patches or sealant for hull or deck planking,[152] galleyware and cookware, including lead braziers, and, for various parts of the bilge pump system, including collecting boxes, pipes and joints.[153] By the Hellenistic period, lead had become an indispensable material of shipboard life, with the potential for well over a ton of lead on a single ship.

Architecture

Architectural use of lead dates back at least to the Archaic period. While the quantity used in a single building project may have been less than that used on a single ship, architectural use was geographically more widespread, and not limited to the coast. In cases of large building projects, the quantity of lead needed may have approached that of an average merchant vessel.

The most recognizable architectural use of lead is the weight for a plumb line. How early it came into use is difficult to say. Amos mentions the architectural aid of a

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[147] While there is no direct evidence of ships carrying sails of different weights for different wind conditions, this is a well-known practice of modern sailing ships and there is no reason to suppose it was not employed in ancient times.
[148] Eiseman and Ridgway (1987, 23-4) indicate this may be intrusive. See also Pulak et al. (1987, 39-41) for a further discussion of lead and stone anti-fouling rings.
[149] Friedman et al. 2002, 346-7.
[150] Friedman et al. 2002, 346.
[151] Ath. 5.204a.
[152] Rosen and Galili 2007, 301.
[153] Rosen and Galili 2007; Galili and Sharvit 1999.

plumb line, although it is not specifically described as lead, and could, in theory have been stone.[154] A later Greek reference in Philippus specifies lead as the weight used for a carpenter's line,[155] but since these are difficult to differentiate archaeologically from fishing weights, clear early examples are lacking. Another lead tool, mentioned by Aristotle, is most likely a flexible rule which can be used to follow the lines of carved or rounded stone.[156] Neither of these applications would have constituted a regular demand for the metal, however, since they were relatively small and presumably architects made an effort to preserve such tools, making regular replacement unnecessary.

A more significant architectural demand for lead came from the practice of connecting stones with clamps or dovetail joints of iron, bronze or wood coated with molten lead.[157] In a few rare cases, the clamp is made of solid lead. The earliest reference to this practice is in Herodotus who claims that Nitocris, a sixth-century B.C.E. queen of Babylon, built a bridge of stones held together with iron and lead.[158] The discovery of lead-filled sockets for the gates of Assos in Asia Minor dating to ca. 600 B.C.E. supports this chronologically.[159] The practice is well attested archaeologically in Greek regions from the sixth through third centuries B.C.E., including at sites such as the fountain of the Castalian Spring and the treasury of Marmara at Delphi, the Agora at Thasos, the temple of Apollo at Delos, and most of the Periclean buildings of the Acropolis in Athens; historical accounts attest to its even more widespread use in later periods.[160] In some cases the joint was coated in lead in advance of being inserted into the stone, in others, it was poured into the joint after the stones were set through channels specially carved in the stone. The former technique was more common for

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[154] *Amos* 7:7-9.
[155] *Anth. Pal.* 6.103.
[156] Arist. *Eth. Nic.* 1137b.30.
[157] See Martin (1965, Table 1) for examples of lead-coated wooden clamps from Delos.
[158] Hdt. 1.186.
[159] Pulsifer (1888, 154-5) notes that much of the lead had been pillaged in antiquity. It is interesting to note that Old Testament lists of materials and experts required for great architectural endeavors never refer to lead or lead workers, suggesting it was not yet a common practice, in the Levantine coastal regions at least. 2 Chronicles (2:7-14) specifically mentions "gold, silver, bronze, iron, stone, and wood, and … purple, blue, and crimson fabrics and fine linen" but no lead, as with 1 Chronicles 22:14-16, and 29:1-5.
[160] For archaeological examples, see Martin (1965, 242-253, 283-4). Textual references include Thucydides (I.93); Vitruvius (*De Arch.* 2.8.4 and 10.2.11); Josephus (*AJ* 15.398).

horizontal joints in stones in the same level, while the latter was needed for vertical joints between levels. Coating joints in lead protected the stone from corrosion of the iron or bronze, while also providing a small amount of flexibility in the joint for expansion and contraction of the stone under different climatic conditions.[161]

It is difficult to estimate the actual quantity of lead used in a single building, let alone in a whole town or region. Certain regions avoided carving joints into building stone altogether, such as in Sicily where local stone was considered too friable to risk weakening with joints.[162] Where the technique was used, different types of joints were often employed in different structures and even within a single structure. Certain joints for example, were rarely used in foundation layers or where they would be visible.[163] Lead was not always used in these joints, and archaeologists are not always able to determine from surviving stones with only the sockets left what material originally filled them. One document sheds some light on this issue. The building records from the sanctuary of Asklepios at Epidauros include several entries on quantities of lead acquired over the years. The records cover a period from 370 to ca. 250 B.C.E., but the most detailed lead references appear in the accounts for the Tholos, dating from ca. 365-335 B.C.E.[164] The four entries list the purchase of 40 talents of lead in the 11th year of construction, 18 talents in the 14th year, 6 talents 37 minae in the 18th year and 100 talents in the same year.[165] This comes to total of 164 talents 37 minae for a building 23 m in diameter and ca. 9 m high.[166] This amount far exceeds the mass of raw iron used (approximately 70 talents), though finished iron fittings are accounted for separately.[167] Most of the published examples of lead use in building construction come from temple buildings and treasuries, suggesting the practice was primarily employed in monumental projects.

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[161] Martin 1965, 238-9.
[162] Dr. Nancy Klein 2009, personal communication.
[163] Martin, 1965, 239-40.
[164] Burford 1969, 10, 208. The Tholos records are contained in *IG* IV^2 I, 103 A and B.
[165] Burford 1969, 181, 220-1. The records are somewhat incomplete, with data on the ceilings, roof and interior pavement not accounted for, so it is possible some additional lead was used.
[166] Burford 1969, 63.
[167] Burford 1969, 181.

By the Classical period we see that the practice of using molten lead to fix an object in place was common enough to rate its own specific Greek verb, μολυβδοκοέω.[168] It was not restricted to joining stone, but was also used to stabilize statuary and burial urns and to affix building accessories such as lamps and plaques, which may have fallen into the purview of architects or other professional craftsmen.[169] Cato, for instance, in the second century B.C.E., describes bringing in a worker to set the joints of an olive press with lead.[170] It is noteworthy that he speaks of buying the lead separately from hiring the workman, suggesting that certain professionals did not necessarily lay in their own supplies, and that the consumer could be expected to acquire it on his own.

To a certain extent the use of lead as a fixative may have penetrated the domestic sphere without recourse to professionals, as indicated by a passage from Aristophanes' *Peace* (421 B.C.E.). [171] An arms dealer, his goods rendered useless due to the peace, wonders to what other use his bugle could be put. Trygaeus suggests two options, one of which is to pour lead into the bell and set a rod into it to act as a target for the drinking game *kottabos*. This implies that non-professionals occasionally availed themselves of such practices for things as ordinary as games. In the Roman period, Juvenal jeeringly speaks of Diogenes repairing his own home with lead clamps, perhaps suggesting that such behavior was associated with those frugal to an absurd extreme.[172]

Counterfeiters

The ubiquity of lead and its ready workability also made it a likely material for less legitimate uses. As we have already seen in the discussion of alloys above, lead played a prominent role in various legitimate and illegitimate alloys in the Roman

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[168] For instance, Aristophanes, *Eccles*. 1110.
[169] References to such uses include Aristophanes (*Eccles. 1110*); Antipater of Sidon (*Anth. Pal.* 9.723); Cicero (*Rep.* 6.8); Pausanias (7.22.2). For affixing accessories, not just molten lead, but lead dowels were also used (Nriagu 1983, 253), a practice also attested on ships, as evidenced by the *ophthalmoi*, or decorative eyes, recovered from the Tektaş Burnu wreck (Carlson 2003, 595).
[170] Cato *De Agr.* 21.5.
[171] Ar. *Peace* 1242-1244.
[172] Juv. 14.310.

period. Such references date back at least as far as the Archaic period, with a recipe for counterfeit silver made up of base metals found in the library of Ashurbanipal (668-627 B.C.E.).[173] Surviving references to lead being used for such nefarious purposes is more common beginning in the Classical period, but this passage indicates that lead probably had a long and storied career among the criminal element. Herodotus relates, though doubtfully, the tale of Polycrates bribing the Lacedaemonians to depart Samos using gilded lead coins.[174] Nepos in the first century B.C.E. claims that Hannibal deposited jars filled with lead and covered with a layer of gold and silver coins into a temple while smuggling his actual wealth out of the city hidden inside bronze statuary.[175] A rather gruesome Roman example from Valerius Maximus speaks of L. Septimuleius adding lead to the head of C. Gracchus, for which he had been promised its weight in gold.[176] Another, somewhat unexpected, source about the seamier uses of lead comes from Pseudo-Aristotle's *Problemata*, in which, while attempting to explain the behavior of objects of different weights, he employs the example of loaded dice.[177] The prevalence of this practice may be indicated by the fact that the act of weighting with lead is represented by a single verb (μολυβδοώ).

Such stories tend to involve famous figures who cannot be classified as "professional" counterfeiters, but the types of substitutions reported may indicate common techniques practiced on a smaller scale by a more professional class of cheat. Circulating artificial coins, falsifying cargo, and defrauding the scales may have been rampant on an everyday scale. Nikophon's coinage law from the Athenian Agora (375/4 B.C.E.) lists silver-plated lead core coins among five types of coins commonly found circulating in Athens.[178] Archaeological evidence reveals many examples of coins involving lead from the Classical through Roman periods, though it can sometimes be

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[173] Moorey (1994, 233) citing Oppenheim 1966.
[174] Hdt. 3.56. For another reference to lead-based counterfeit coinage, see Appian 1.6.44.
[175] Nep. *Hannibal* 9.3.
[176] Val. Max. 9.4.3.
[177] Arist. [*Pr*.] 913a36.
[178] Van Alfen 2005, 322.

difficult to distinguish between independent criminal activity and government-sanctioned debasement.[179]

It is not possible to calculate the amount of lead channeled into illicit activities. Some instances must have been sporadic and opportunistic, perhaps qualifying as domestic uses, while others were more organized and large-scale.

Medical

Based on Greek texts, lead components had found a place in the medical field by the Classical period. No less than eight lead-based medical applications are cited in Hippocrates. Six involve recipes for various compresses or topical ointments for treating wounds, lesions or hemorrhoids.[180] Two are skeletal in nature, one recommending use of a lead shoe sole for the correction of club foot, and one referring to the practice (not universally followed) of binding a broken collar bone with lead.[181] Whether the material used in the ointments was derived from processed metallic lead rather than lead minerals is difficult to ascertain. The word most commonly used for lead in the various Greek recipes is μολυβδαίνα, a word often used to indicate fishing weights and sling bullets, but translated by some scholars in this context as galena.[182] If galena is meant, then it is likely more localized sources were utilized where possible, since the expensive infrastructure of full-scale lead-silver mining and processing would not have been required.[183]

In the Roman period, evidence for the use of metallic lead in ointments is more firmly attested. Topical treatments for open wounds, scars, eyes and hemorrhoids are described in Celsus and Pliny, who speak in some cases of melting lead or grinding it

[179] Van Alfen 2005, 322-3. Further discussion of official use of lead-based coinage will be included in the section on infrastructural uses.
[180] Hippoc. *De Ulceribus* 13, 14, 16 and 21; *De Fistulis* 10, *De Haemorrhoidibus* 8.
[181] Hippoc. *Art.* 62 and 14.
[182] While it seems strange to use the same word for metallic lead and its source mineral, galena would have been easier to render into powdered form to mix with the other ingredients.
[183] While galena deposits are relatively widespread, the mining and processing of lead was less common, as will be discussed in chapter 2.

into a sort of rough paste (*donec crassescat*) to leach into a liquid.[184] Other terms such as *plumbum combustum, scobem plumbi*, *cerussam*, and *plumbaginem* show that various mineral and modified forms of lead were also commonly used. The instructions in Pliny indicate that practitioners would, or at least could, do their own grinding and processing, however, certain ready-made mineral products may have been available. Several cargoes of lead minerals have been discovered from the Archaic through Roman periods, which indicate such products were available.[185] Since many of these minerals were also used for pigments and cosmetics (discussed below), it is difficult to determine how much of this material would have gone to medical practitioners rather than artisans or domestic consumers.

In addition to use in medicines themselves, Celsus described tubes that could be either of lead or bronze for draining the abdominal cavity.[186] The ease with which lead can be formed into tubes, given a ready supply of sheet lead, may have provided a cheap alternative to the more expensive cast bronze implements often used for medical equipment.[187]

Artisans

A variety of artisans drew on lead as an ingredient in their work. Some dealt in pure lead objects, such as the figurines or sarcophagi discussed above, but many others used lead or lead minerals to affect the properties of the material in which they specialized.

Leaded bronze, first explicitly described by Pliny in the first century C.E., actually arises as a common phenomenon in the Bronze Age.[188] Nriagu believes that "[o]n a qualitative basis, nonferrous metal alloys represented the principal commercial

[184] Celsus *Med.* 5.1; melting described in Pliny (*HN* 34.166); grinding in (*HN* 34.168).
[185] Wrecks containing lead minerals include the Mazarrón 2 (**4**), Planier C (**24**), Agde G (**13**), and Mljet (**52**).
[186] Celsus *Med.* 7.15.2.
[187] Surviving examples of ancient medical equipment, such as those from the House of the Surgeon in Pompeii, are primarily of bronze (Cagnat and Chapot 1920, 2:514).
[188] Partington (1935, 249, cited in Nriagu 1983, 206) presents a recipe from Early Bronze Age Sumeria which appears to call for lead (*anna*) but there is room for debate over the proper rendering of this term.

application for lead in preclassical times."[189] The wide variety of alloy compositions involving lead identified in the early development of metal technology in various areas led Tylecote to state that realistically "[i]t is therefore better to divide the [Bronze Age] into two: the earlier, experimental age, and the later, full Bronze Age."[190] Moorey, for instance, notes that in the Near East, leaded bronze is found in many places in the Early Bronze Age, but drops off significantly in the Middle Bronze Age in the same region.[191] By the Late Bronze Age, examples can be found in the Aegean, Mesopotamia, and Egypt.[192] On examining a variety of bronze artifacts from Late Bronze Age Aegean contexts, Craddock notes that lead was primarily employed for artistic applications, mostly statuettes, rather than items requiring strength, such as swords, tripods and bowls.[193] Further examination of Archaic through Hellenistic Greek copper-alloy artifacts reveals a similar pattern in lead use, with the addition of high lead content in handles.[194] Nriagu notes that hammering and other fabrication processes may have been hindered by higher lead contents, and thus its use was limited primarily to cast items.[195] As indicated by Pliny, leaded bronze was commonly used for statuary during the Roman period, but other decorative cast bronze items common in the Hellenistic and Roman world include figurines, lamps, lamp stands, furniture feet and handles, and mirrors. Some utilitarian uses attested archaeologically include cables, pumps, stop-cocks and valves.[196] Craddock notes that the axles of some Roman waterwheels found in mines were of leaded bronze perhaps to increase their resistance to the corrosive environment.[197]

[189] Nriagu 1983, 205; though I would argue that demand from cupellation may have rivaled this.
[190] Tylecote 1992, 18.
[191] Moorey 1994, 294-6.
[192] Nriagu 1983, 205-7.
[193] Craddock 1976
[194] Craddock 1977
[195] Nriagu 1983, 207.
[196] Plin. *HN* 34.95-97 (if *plumbum argentarium* is interpreted as some form of lead); 34.98 calls for both *plumbum nigrum* and *plumbum argentarium*; for utilitarian applications, see Nriagu 1983, 208.
[197] Craddock 1995, 78.

Lead in the form of lead oxide (PbO) was a common additive to glass beginning in the 15th century B.C.E. in Mesopotamia and Egypt.[198] This compound lowers the softening temperature of glass and increases its density, as well as rendering the final product softer for easier cutting and engraving.[199] It also acts as an opacifier, and was frequently used in conjunction with antimony to create solid yellow and solid green glasses.[200] Based on Late Bronze Age examples from Egypt, the lead antimoniate pigment was most likely prepared by roasting antimony oxides with lead oxide, and then the pigment was mixed in with raw glass prepared previously and, perhaps, elsewhere.[201] Of the 19 yellow glass samples analyzed by Shortland and Eremin, the highest lead content recorded was 8.97% and the lowest 0.68%, attesting to a wide variety of recipes used at this early stage.[202] Lead as an ingredient in red glass is also attested in several Mesopotamian cuneiform tablets as early as the Late Bronze Age, and archaeological examples, often in the form of enamels on metal, have been found from Hellenistic and Roman sites with a variety of compositions, generally ranging from 1 to 30% lead content.[203]

Pottery glazes could also contain lead. High-lead glazes, such as those later made famous by Islamic glassmakers, generally containing 45-60% lead, do not appear until the first century B.C.E. and wane in the first century C.E.[204] Some earlier glazes contained low amounts of lead as a pigment. Several types of paint also used lead minerals for color, including cerussite for white, and a false minium (or red lead) for red. These would have been in demand by professionals such as artists, house painters, and even ship painters.[205] Evidence from Roman pigment shops containing a wide variety of crushed minerals suggests that such shop owners should be considered a class of

[198] Nriagu 1983, 224.
[199] Moorey 1994, 207; Nriagu 1983, 223.
[200] Shortland and Eremin 2006, 592.
[201] Shortland and Eremin 2006, 592 citing Shortland 2002.
[202] Shortland and Eremin 2006, Table 2.
[203] Nriagu 1983, 225-231.
[204] Tite et al. 1998, 242.
[205] See Colombini et al. (2003) for evidence of lead-based paints on ships.

professional, relying upon a steady supply of moderate volumes of lead minerals to satisfy his or her customers.[206]

Military Applications

This category covers use in active military campaigns, and presupposes state-supplied, intensive use for limited periods in changing regions. The internal uses within military forts are similar to those in cities, and will be considered below in the section on infrastructural demands. This section focuses on specific combat applications for both land and naval forces. However, inasmuch as infrastructural uses combined with combat uses to influence trade routes and resource exploitation, they must be considered together when estimating the weight of military demand on the lead supply.

Compared to iron and bronze, there was little demand for lead in the military sphere. As a component of bronze, there was some demand for lead, but as lead improved castability, not strength, high-lead bronzes were not ideal for most weaponry applications. Such appears to have been the case for naval ship rams, a large piece of cast bronze fitted over the prow of a ship at the waterline. Studies done on the Athlit ram, found off the coast of Israel in 1980, show that the bronze contained “virtually no lead.”[207] This ram dates to the Hellenistic period, and it would be interesting to see whether such composition was maintained in Roman times, when lead was much more widely used in bronze statuary.

Other naval applications, for the most part, would have mirrored the nautical applications described above, so for wars involving frequent naval engagements, such as the Peloponnesian and the Punic Wars, lead would have been an important resource. Under the Roman Empire, suppression of pirates was also a high priority, requiring a well-fitted fleet of combat ships.

In land warfare, the primary application of lead was for sling bullets. In the Bronze Age, these were usually of stone or clay, though Evans reports finding two lead

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[206] Becker and Wilke 2011.
[207] Oron 2006, 69. While information on other rams has been published (Pridemore 1996), metallurgical studies are so far rare.

bullets in a Late Minoan context in Knossos; such examples are, however, very rare.[208] By the Classical period, stone bullets persisted, but lead and also clay were increasingly employed.[209] Xenophon, writing of the harrowing escape of the Greek army trapped in Persia ca. 400 B.C.E., tells us:

> I hear there are, among our troops, Rhodians, many of whom, they say, know how to use a sling, and their missiles fly at least twice as far as those of the Persian slingers. For the latter, using slings with stones as large as a hand, have only a short reach, but the Rhodians know how to attack with lead bullets.[210]

Modern experiments with lead sling shot support claims to lead's superiority, showing that the path taken by such missiles is very direct, unlike stone bullets which "seem to leave their line of fire more easily, and are more likely to miss their target."[211] According to Xenophon, 200 Rhodian slingers and 50 horsemen proceeded to drive off 4,000 troops and 1,000 horsemen of Mithridates' army, and that the range of the Rhodian slingers actually exceeded that of the Persian archers.[212] No one will deny that iron and bronze were the most important metals for the ancient soldier, but here is an interesting case where the use of lead provided a tactical advantage.[213]

It is also interesting to note that Xenophon speaks of the slingers being able to find sufficient lead to arm their slingers.[214] At this point, the fleeing army is somewhere in the vicinity of the ruins of Nineveh. That this grand Mesopotamian city and its

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[208] Evans 1964, 2, 344.
[209] The earliest bullet Krysko (1979, 53 and Fig. 51) presents is from 600 B.C.E., most likely from Knossos, but Foss (1975, 30) describes a bullet marked Tissaphernes from ca. 401-395 B.C.E. as the earliest known dated lead sling bullet.
[210] Xen. *An.* 3.3.16-17.
[211] Bosman 1995, 101.
[212] Xen. *An.* 3.4.16-17.
[213] Other accounts of the tactical application of slingers include Livy (38.29.6), who reports that slingers were recruited for use in defending siege works from sallies by the besieged Sameans, and *De Bello Africo* (83), in which slingers, using both stone and lead shot, are reported as being useful in disordering the ranks of elephants.
[214] Xen. *An.* 3.4.17.

environs left behind an abundance of lead to be scavenged suggests a substantial use of lead, at least in Near Eastern trading centers, in the Archaic period.

In Xenophon's example, the lead used was recycled from scrap metal out of necessity, but the practice may have continued even for well-supplied units in the field when supplies dwindled during battle. Lead bullets often bore messages or legionary insignia cast into the form, especially during the Roman period, suggesting soldiers may have cast their own bullets using a personal or legionary mold similar to those used by fishermen to cast their net sinkers.[215] Analysis of shot from the Roman fortress site of Velsen I in the Netherlands, however, revealed five distinctive types, only one of which was clearly cast in a mold; of the others, three were produced by casting in holes in sand made by sticks or similar instruments, and the final was cast in holes made by fingertips.[216] This suggests that stocks of premade bullets could be easily exhausted in the course of battle and that casting could actually take place in the midst of battle, implying that supplies of metal were carried, if not by the slingers themselves, then by supporting personnel moving with or stationed near them.

By the Roman period, sling bullets, possibly the most commonly-referenced use of lead in the Roman period,[217] had become the means for the transmission of both secret messages and propaganda. The author of *Bellum Africum* reports that Caesar's troops received a promise of surrender from one enemy soldier by this method.[218] Appian in the second century C.E. claims that Greeks disclosed information to the Romans during the Mithridatic wars via messages inscribed on lead bullets.[219] Archaeological finds attest to names, symbols, and threats though no lengthy messages have so far been found.[220]

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[215] Galili et al. 2002, Fig. 13a&b.
[216] Bosman 1995, 99.
[217] I found no less than 25 references to bullets out of a total of approximately 200 citations from this period.
[218] *B Afr*. 13.
[219] Appian 12.5.33. As this story is ascribed to the Hellenistic period, it may be a practice that dates back at least to that period.
[220] See Foss (1974, 27-8) for common Greek inscriptions; certain threatening words, including "conquer" (*nika*) and "blood" (*haima*), could also be seen in part as having a magical goal, imbuing the bullet with good luck for the slinger, in addition to intimidating the enemy. For a collection of inscribed Roman bullets for Iberia see Díaz Ariño (2005, 233ff.); many of these bear the name of the rebel general Sertorius

One also finds lead to have been a common component of siege defenses. The seaborne siege of Achradina by Marcellus in 214 B.C.E. was foiled by grappling hooks counterweighted with lead.[221] Livy reports dropping heavy stones and lead counterweights from city walls onto battering rams during the siege of Haliartus in 171 B.C.E. and the siege of Ambracia in 189 B.C.E.[222] The lead used for this most likely consisted of reused lead appropriated from supplies within the besieged cities, and, if any counterweights or missiles actually survived further reuse, these would be difficult to identify in the archaeological record as their form was likely rudimentary.

Valerius Maximus, in the first c. C.E., reports the stratagem of laying out leaded boards with nails sticking out to protect siege works from being sabotaged in the night.[223] Tacitus claims that the emperor Nero attempted to have his mother, Agrippina, assassinated by having his agents drop a canopy weighted with lead upon her.[224] In later Roman sources we also hear of lead being used in torture devices such as the rack and as tips of whip ends.[225] Such uses were rare for the most part and do not represent a significant demand, but do show the extent to which lead was incorporated into military stratagems in the Roman period.

Overall, in earlier periods, the military demand for lead was likely limited to the fitting out of ships by the predominant naval powers, and to some extent supplying slingers with ammunition. The military demand by Roman legions in the areas in which they were stationed, however, was significant. In *Bellum Africum* the chronicler reports that Caesar

> …ensured that iron workshops were established, a plentiful supply of spears and arrows built up, bullets cast, stakes collected, and messengers sent to Sicily with

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along with propagandistic terms like "piety" (*pietas*), "trust" (*fides*), and "justice" (*ius*); some carried a legionary designation, and others a lightning bolt with the slogan "take it" (*accipe*).

[221] Polyb. 8.7; Livy 24.34.10-12.

[222] Livy 42.63.4, 38.5.3-5. Tacitus (*Hist.* 2.21) also lists masses of lead as one of the defense supplies amassed by the followers of Otho against the onslaught of the forces of Vitellius in 69 C.E..

[223] Val. Max. 3.7.2.

[224] Tac. *Ann.* 14.5; Agrippina was reportedly saved by the fortitude of the couch upon which she laid.

[225] Amm. Marc. 28.1.29, 29.1.23, 29.1.40, 30.5.10.

> dispatches requesting they gather for him fascines and material for battering rams, which Africa lacked, and that iron and lead be sent.[226]

Here we see that pre-made bullets were considered a standard constituent of campaign supplies, and that the need for additional raw lead was significant enough to merit importation into the theater of war.

Infrastructural Applications

Uses supporting the functioning of the state and public life were primarily the sphere of the government, but, depending on the time and region, there could also be an aspect of private support. Particularly in democratic societies, such Classical Athens and the Roman Republic, the donation of public works by elite citizens or families was an expected aspect of public life. These often took the form of building projects, which involved some use of lead through architectural professionals, but with the advent of lead plumbing, projects involving high volumes of lead, such as fountains, bath complexes and even aqueducts, might be funded through public or private sources.

Pipes are the most well-known use of lead in the ancient world, but were a relatively late development. Occasional, relatively small examples have been found in Near Eastern contexts from the Bronze Age and later,[227] but it is difficult to know if their rarity is related the lack of use or to extensive recycling. Pipes as part of bilge systems on ships have been dated to the Hellenstic period.[228] Extensive use of lead pipes, however, as part of large-scale water management does not arise until the first century B.C.E.; prior to this, pipes were primarily made of ceramic.[229] Roman pipes were formed

[226] Caes. *B Afr.* 20.
[227] Nriagu (1983, 242) cites examples from Ur and Kish in Mesopotamia and an early Iron Age lead pipe from Musyan near Persia, but these are not well documented.
[228] Pulak et al. 1987, 36-8.
[229] Vitruvius (*De Arch.* 8.6.1), writing in second half of the first century B.C.E., is the earliest extant author to address issues involving lead pipes specifically. He points out that water was supplied to cities using three methods: artificial channels, ceramic pipes and lead pipes (*Ductus autem aquae fiunt generibus tribus: rivis per canales structiles, aut fistulis plumbeis, seu tubulis fictilibus*). If lead pipes were in common use by Vitrivius's time, the adoption of this technique may date somewhat earlier, perhaps to the

from cast lead sheet bent around a form, probably of wood, then soldered or welded along the seam with either pure lead or a lead/tin alloy. In the Imperial period, pipes were standardized at 10 Roman feet (2.96 m) in a range of thicknesses and diameters depending on need.[230]

As extensive as the Roman aqueduct system was, the lead components were generally restricted to urban sections where water was distributed from a point where the main channel reaches the city.[231] The long-distance portions were primarily underground stone channels, combined with ceramic pipes and the great arched bridges across valleys and rivers, which carried water in an open channel of stone, masonry or concrete.[232] The main exception to this are inverted siphons, used to cross deep valleys or sometimes rivers, when the depth exceeded the height of safe bridge construction.[233] In such cases, a reservoir tank was built on the upstream side of the valley, out of which a single, large lead pipe or series of smaller, parallel pipes ran down the valley wall across the floor and up the opposite side, into a receiving tank that was positioned at a slightly lower elevation than the starting point. Water thus ran for a great distance under pressures of up to 10 atmospheres.[234] Lead was a common medium for high pressure pipes in the Roman period, though stone and ceramic examples have been found.[235] Such installations could require a great deal of lead – the Beaunant siphon, one of nine

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early first century, which coincides with the time when large quantities of lead began to be exported from Spain.

[230] Hodge 2002, 309-10; Vitr. *De Arch.* 8.6.4. Landels (1978, Table 1) compiled a table of standard Roman pipe diameters, with corresponding weight calculations, taken from Vitruvius (*De Arch.* 8.6.4), who states that a 10-*pedes* length of the largest pipe, 100 *digiti*, should weigh 1200 *librae* (392.4 kg). Vitruvius does not provide a pipe thickness, but calculations reveal his figures are based on a pipe thickness of 1/3 of a *digitus* (.64 cm). Thicker pipes, particularly in high pressure siphons, however, may have been employed, resulting in deviations from the expected weights.

[231] Hodge 2002, 110.

[232] Hodge 2002, 105ff. Hodge (2002, 111) also notes that in northern Europe, wooden pipes were common.

[233] Many scholars have claimed that the Romans did not use inverted siphons, but Hodge (2002, 147) has identified nearly two dozen examples, noting that aqueduct bridges do not exceed 50 m in height, and all siphons so far identified, at least in the west, range between 70 and 123 m (Hodge 2002, 155-6), suggesting there were clear criteria for selecting one method over the other.

[234] The Beaunant siphon ran 2.6 km, but all pipes together amounted to approximately 23 km, with an overall change in elevation of 123 m (Hodge 2002, 155-6).

[235] Stenton and Coulton (1986, 46) point out that stone pressure pipes were more common in Asia Minor even in the Roman period. Hodge (2002, 110-11) notes that some of the stone pressure pipes may date to the Hellenistic period, but accurate dating of these is very difficult.

siphons serving the city of Lugdunum (Lyon), had nine parallel pipes, with an estimated 2,000 tons of lead; all nine siphons together may have required from 10,000 to 15,000 tons.[236]

In the urban setting, lead was used for local delivery pipes; water storage tanks in public water towers, private homes, and baths; and specialized fittings at junctures.[237] In addition, basins for fountains and baths were sometimes lined with lead sheeting, and lead-lined cisterns were used in many areas.[238] The Great Bath at Bath, for example, is lined with lead sheets 2.5 cm thick, and with dimensions of 24 m x 12 m x 1.65 m, for an estimated total of 8.6 tons.[239]

Working with lead plumbing was considered a specialized skill in the Roman period, as evidenced by Vitruvius who recommended ceramic pipes over lead because they were easier to repair.[240] This is further supported by the fact that there were two permanent gangs of lead workers (*plumbarii*) in the city of Rome alone, to service the water system.[241] That a regular labor force was established to handle the city's plumbing needs indicates there was a constant, though perhaps moderate, demand for lead to

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[236] Hodge 2002, 155. The fact that the majority of known siphons have been found in Gaul and Spain may in part be related to the availability of lead in these regions. Hodge (2002, 156-7) points out that the difficulty of transporting lead pipe segments and soldering them in place may have been much more expensive then building bridges out of local stone with relatively low transport costs. The soldering process was complicated by the fact that the pipes were buried, necessitating the action take place inside a small trench.

[237] Rare surviving examples of lead storage tanks as part of urban distribution systems have been discovered at Pompeii and Novae, Bulgaria (Hodge 2002, 301). For an example of a lead junction box from Pompeii, see Hodge (2002, Fig. 225).

[238] Tylecote 1992, 72.

[239] Hodge 2002, 263-4.

[240] Vitr. *De Arch.* 8.6.10. He also preferred ceramic pipes for the cleanliness of the water that passes through them, suggesting that Romans were aware of some of the risky aspects of using lead pipes. Vitruvius supports this idea by noting that lead pipes produce *cerussa*, known to be poisonous, which could contaminate water coming into contact with it. In this case, however, he may have mistaken lead carbonate (*cerussa*) with another white, powdery substance, calcium carbonate, a common deposit in lead pipes carrying hard water, which actually acts as a barrier to lead contamination (see Hodge 1981, 85). The oft-debated question of lead poisoning in antiquity will not be discussed here; it is covered quite thoroughly in Nriagu 1983 and later responses.

[241] Frontin. *Aq.* 116. Frontinus was *curator aquarum* for the city of Rome in 97 C.E., and left a remarkable record of the issues involved in supplying the city with water. He relates that there were two gangs of *plumbarii* in Rome, all slaves, one donated to Augustus by Agrippa and thereupon given to the state, and one established by Claudius for the construction of an aqueduct that remained in the private hands of the emperor.

maintain the system, punctuated by periods of high demand when new projects were instituted.[242]

While large bath complexes were generally built by the government, other small and moderate complexes were built by private citizens and donated for public use; many more were smaller, privately-owned installations, most likely fitted out by professional lead workers on a contract basis.[243] For households that could afford a private water grant, plumbing within the house was most likely also installed by privately-contracted professionals.[244] Frontinus, speaking of public water illegally diverted by private citizens in the city of Rome, says "[h]ow large an amount of water has been stolen in this manner, I estimate by means of the fact that a considerable quantity of lead has been brought in by the removal of that kind of branch pipes."[245] Such private use of lead pipes may represent individual, opportunistic use of roughly made shunts, or may be symptomatic of an organized criminal operation or perhaps a corrupt sideline of professional lead-workers (either free or slave).

Currency

Well before the advent of official state coinage, a common currency of trade in the Near East was silver. By the second millennium B.C.E., and increasingly during the first half of the first millennium, Egypt, Babylonia, Assyria and the Levant all used, though not exclusively, silver as a standard of value, and, to some extent, as a medium of exchange.[246] This silver took no regular shape and was traded by weight, being measured each time it was traded. Described as "rings, bars, and broken bits of silver,"

[242] It must be noted that the duties of these men likely also included cleaning the calcium carbonate from the pipes, a very time consuming chore, and thus, despite their name, they may not have spent much of their time actually working with lead.

[243] Nriagu (1983, 239, citing Forbes 1964) provides a breakdown of baths in Rome in the fourth century C.E. as 11 public, 852 private, along with 1352 cisterns and fountains. Some of these might have incorporated cheaper plumbing options such as ceramic pipes or masonry channels where possible.

[244] For a discussion of private access to the public water supply, see Bruun (1991, 63ff).

[245] Frontin. *Aq.* 115.

[246] Schaps 2004, 39-56. Other media of exchange included grain, livestock and textiles. On use as a standard of value, Schaps points out (39) that in New Kingdom Egypt "[h] ouses and animals were regularly sold for a price quoted in silver or copper. In reality, however, it was rarely silver or copper that changed hands."

hoards of so-called *Hacksilber* have been found, which show how silver for trade could be easily weighed, and, when needed, chopped up into smaller pieces as transactions required.[247] There was no supervision of silver purity, and gradual adulteration with copper and other metals may have occurred.

As already discussed, in order to refine silver, lead was required for cupellation. Due to the difficulties of transporting lead ore over land, most Bronze Age silver is presumed to have been refined at or near the extraction point; however the need to reuse and purify circulating metals in urban areas may have necessitated a stable supply of lead. The supply of lead found at the Late Bronze Age site of Ras Ibn Hani might be evidence of this type of use.[248]

Egyptian records from the 18th dynasty, for example, reveal several instances of lead being received as tribute from the nations of Retenu, Isy, and Zahi.[249] As tribute, it would have been state property, and given the low frequency of lead artifacts from Egypt, it is likely that it was needed for cupellation of silver, which was imported into Egypt in abundance both as tribute and spoils of war. Lead may also have been used in refining gold, an indigenous Egyptian resource widely exported to the Near East.[250]

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[247] Schaps 2004, 49.

[248] Bounni et al. (1998, 48-9) note that there may have been too much antimony in the lead for successful cupellation, and that the lead may have been intended to hold powdered corundum, in the manner of modern sandpaper, and used to polish stone.

[249] Breasted 1906, II §§460, 462, 471, 491, 493, 509, 521, 534, 558. To date, no one has expressed any doubt as to the translation of *d[.]hty* here as lead, though Nriagu (1983, 2-3), citing Wreszinski (1912), allows that the hieroglyphic terms for tin and lead were difficult to distinguish prior to the New Kingdom when a modifier meaning “white” was added to tin. In almost of all the examples above “lead” is listed immediately after copper, and in all cases tin is noticeably absent. In two cases the quantities of both metals are preserved (Breasted 1906, II §509, §491), showing Cu:Pb ratio of 10:1 and 7:1. As this is the range one would expect for copper and tin to make bronze, it is suspicious that tin is not in this list. The Late Bronze Age shipwreck at Uluburun contained copper and tin ingots in a ratio of 10:1, thus establishing an archaeological precedent for the transport of copper and tin together. I am not convinced, therefore, that the lead cited in these cases is not tin, especially since Egypt had its own sources of lead, and no native tin deposits. While lead isotope analysis suggests that lead metal artifacts from 18th dynasty Egypt were made of imported lead rather than local ores, isotopic signatures from sampled artifacts are possibly consistent with Mesopotamian ores, suggesting an eastward rather than northern source for lead imports (Shortland 2003, 190). Further investigation is warranted to see if there could have been some dual application of the term, as we have seen already for Akkadian and Latin.

[250] Diodorus Siculus (3.14) attests to the use of lead in refining gold in Roman Egypt and surrounding areas.

References to silver as currency abound in the Old Testament. Not coincidentally, one also finds therein several references to the use of lead in metallurgy, usually as a metaphor for the purification of sinners. These passages are frequently cited by scholars to help analyze the metallurgical techniques in use in the Archaic Levant. In Ezekiel (22:17-22), for example, the men of Israel are compared to an array of different metals to be gathered together and melted by the fire of God's wrath.[251] The metallurgical process is not described in detail, though it does speak of blowing fire across the metals, as is consistent with the use of the bellows for artificial drafts.[252]

In these metaphors, lead is always listed as part of a collection of different metals, making the references too generalized to illuminate much in respect to lead specifically. At least one passage, however, provides a clear reference to cupellation:

> [28]They are all grievous revolters, walking with slanders: they are brass and iron; they are all corrupters.
> [29]The bellows are burned, the lead is consumed of the fire; the founder melteth in vain: for the wicked are not plucked away.
> [30]Reprobate silver shall men call them, because the Lord hath rejected them.[253]

Psalms (12:6), while not mentioning lead specifically, speaks of "silver refined in a furnace on the ground, purified seven times." This observation on the multiple applications of lead required to fully extract the base metals from silver further confirms the use of cupellation and proves a familiarity with the procedure. The description of the furnace of clay or earth is as detailed a reference to the clay cupels needed to absorb the litharge during cupellation as we can expect to find in a metaphorical verse.

In addition to the three passages cited above, there are no fewer than seven other instances of the metallurgical purification metaphor.[254] While only one (Isaiah 1:22-25) mentions lead specifically, the others speak of refining silver, which implies that lead

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[251] Silver, bronze, iron, tin and lead are specified.
[252] Pulsifer (1888, 137) cites this as a reference to cupellation; however, since this process was only used on silver, and no procedure would have involved combining all the metals in question in one furnace, the reference must be considered to encompass metallurgy as a broad category.
[253] Jeremiah 5:28-30.
[254] Malachi 3:1-3; Zechariah 9:1-4; Zechariah 13:9; Isaiah 22:5: Isaiah 48:10; Proverbs 25:4-5; Psalms 66:10.

must have been involved. The occurrence of these passages gives us a clue as to how vital lead was to the metallurgical process during the Archaic period. While lead has been considered useless by some scholars,[255] the growing dependence of ancient societies on gold and silver for currency and commerce required a concomitant, yet less visible, dependence on lead for refining and purification, a dependence clearly reflected in the literature of the time.

With the advent of official coinage, the responsibility for silver purity fell more solidly into state hands, and mints likely required on-site cupellation capabilities. The oldest coins from the Mediterranean world so far known, the electrum issues discovered by Hogarth beneath the Artemision in Ephesus, date back to the late seventh or early sixth century B.C.E.[256] This quickly shifted into a silver-dominated system in Greece, while gold coins remained predominant in some parts of Persia.[257] Though silver and gold would have been imported from initial extraction sources in their purest form, the frequent use of spoils of war and growing recycling of worn coins themselves, suggests a need for refining at the mint itself.[258]

It has been shown that early Imperial silver coinage shows very controlled levels of debasement with copper, which would require pure initial metals, as well as necessitating the extraction of copper from the silver when recycling such currency.[259] Though direct archaeological evidence for large-scale mint sites is restricted to Athens and Rome,[260] several sites from Roman Britain show evidence of cupellation in relation to copper and silver, leading their excavators to suspect coin-related processing.[261]

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[255] Forbes (1964, 197) states that lead is “entirely wanting in physical properties needed in weapons and implements...[and] a worthless constituent of bronze when used as a substitute for tin.” He further states that it “was not widely used before Roman times,” which assertion I hope I have demonstrated is false.
[256] Schaps 2004, 95-6.
[257] Howgego 1995, 46.
[258] Ponting et al. 2003, 592.
[259] Butcher and Ponting 2005.
[260] Howgego 1995, 26-7.
[261] Tylecote (1986, 60) summarizes evidence from finds at Silchester, Wroxeter, and Hengistbury Head. The sites are linked to minting activity primarily due to the composition of the metal remains found at the site, but other evidence for state operation of the hearths are lacking. Some of the hearths may have simply been involved in cupelling silver from copper ores, a more reliable source of lead in Britain than galena.

To some extent, there was also call for lead in the currency itself. Demosthenes, in the mid-fourth century B.C.E., compares the debasement of laws to the debasement of currency, stating that some nations openly adulterate their coins with copper and lead.[262] Data on copper coinage dating from the fourth century B.C.E. through the fourth century C.E. show a wide variation in lead content, with some of the highest levels coming from late Hellenstic Egypt and Republican Rome.[263] The Republican period shows the greatest variation of copper/tin/lead ratios overall, leading Nriagu to conclude that during this period they reused old metals without worrying much about their precise compositions.[264] This suggests that cupellation in mints producing copper coinage, which tended to be local mints with only regional distribution, may not have been intensively practiced. There is also evidence for official issues of lead-core coins during times of economic difficulty in both Greece and Rome.[265]

Small tokens of lead, or *tesserae*, also circulated at local levels and may have acted in a similar fashion to currency. Dating back as far as LBA Mesopotamia,[266] these objects were usually stamped with a design or emblem, rather than words, and could have been issued both by government bodies and private enterprises. Examples from fifth century B.C.E. Athens fulfilled a wide variety of functions from tax receipts to theater reservations.[267] In the city of Rome *tesserae frumentariae* were widely used as tokens for receiving the grain dole.[268] These were government-issued, and Thornton makes an excellent case for the evolution of these into a de facto coinage or “peasants’ money.”[269] Plautus, in the second century B.C.E., makes many references to cheap lead-

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[262] Dem. *Against Timocrates* 24.214.
[263] Nriagu 1983, Table 4.3. The highest lead percentage cited is 32% in an undated Roman-period coin from Athens, and several examples of over 25% can be found in Hellenistic and Imperial Egypt, and the Roman Republic. Nriagu compiled data from several sources without providing details on the testing methods used; due to the difficulty of accurately assessing coin compositions, there may be some inaccuracies in the data (Butcher and Ponting 1995, 66-7).
[264] Nriagu 1983, 216.
[265] Thornton (1980, 338) proposes a hiatus in bronze coinage from ca. 52 to 64 C.E., which was dealt with by the government issuing lead *tesserae* that served as coinage instead.
[266] Krysko (1979, 56) notes lead tokens with erotic designs found near the Ishtar Temple in Assur dating to ca. 1300 B.C.E.
[267] Krysko 1979, 56.
[268] Thornton 1980, 338.
[269] Thronton 1980, 338-9.

based coinage (*plumbei nummi)*, frequently in relation to slaves.[270] While some interpret these as references to counterfeit pieces, it is also possible that these sources refer to the use of various lead tokens as a means of barter or trade among the lowest classes of society.

CONCLUSION

The overall picture to emerge from this evidence is one of early experimental use of lead, which settles, by the Late Bronze Age (1550-1200 B.C), into occasional applications in fishing, votive art, and minor domestic applications, with a possibly more widespread use in refining precious metals. At the end of the Archaic period (ca. 800-510 B.C.E.) applications appear to diversify and intensify, particularly in the Aegean, concomitant with the development of coinage, also centered in the Greek world. Through the Classical and Hellenistic periods (510-146 B.C.E.) we see increasingly widespread professional and infrastructural uses, which proliferate during the Roman period (146 B.C.E. – 476 C.E.) into a virtual dependence on the metal for a well-functioning population center, be it a civic settlement or military fortress. A decline in use can be perceived as early as the third century C.E., which may be related to the decline in silver coinage in favor of gold.[271] This pattern of growth is supported by research on environmental lead pollution based on ice cores and peat bog samples, which shows a slow but steady increase in atmospheric lead levels beginning in the first millennium B.C.E., rising more steeply starting ca. 400 B.C.E. and finally peaking in the first century B.C.E. and first century C.E.[272] While much of this activity was directly related to silver extraction, the spread of lead uses throughout the Mediterranean, Near East and Europe over this period testifies to the intense integration of this utilitarian metal into the ancient economy.

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[270] Plaut. *Cas.* 258; *Trin.* 362; *Mostell.* 892. For a later reference to '*plumbeos'* as cheap coinage, see Martial (10.74.4).
[271] Howgego 1995, 12.
[272] Hong *et al.* 1994; Rosman *et al.* 1997; Shotyk 2002; Roux *et al.* 2004.

CHAPTER III
THE ECONOMY OF LEAD: MINING, PRODUCTION, AND TRANSPORT

Si ulli essent inferi, iam profecto illos avaritiae atque luxuriae cuniculi refodissent.[273]

– Pliny (*HN* 2.158)

Metals involve two separate stages of complex production, often widely separated geographically.[274] The primary stage of production consists of the extraction of ore from the earth, washing and crushing the ore, then processing the ore through various heat-based treatments in order to separate out the non-metallic elements and any unwanted metallic components. Once the desired metal is in as pure a form as possible, it is ready to move to the hands of the artisans who will shape it into a finished object, the secondary stage of production. The skills involved in these two aspects of metallurgy have some similarities, yet the first stage is heavily engineering-oriented, while the second is more artisanal, concerned with the properties of the finished product, be it a statue, a sword or a pipe, and how the metal can be manipulated to yield the best results.

Artisans in the ancient world tended to reside in or near population centers where a ready market for their goods was at hand. Miners, on the other hand, were required to go where the ore was located, and processing the metal as close to the mine source as possible saved on transportation costs, since no effort was expended on moving waste materials. As lead itself was a consistently cheap metal in comparison to others, there was always a fine line between profitability and failure. A closer examination of the steps involved helps to shed light on the economic issues involved in the primary production and circulation of lead.

[273] "If there were any dwellers of the underworld, surely the burrowings of greed and luxury would have dug them up already."

[274] Stone, too, was often extracted, and sometimes roughly shaped, very far from the final utilization point, but did not have to undergo such complex alteration at the extraction point; still the two materials have many logistical issues in common. Clay for ceramics must also be mixed and prepared before it is ready for formation into vessels, but it is generally understood that the ancient potter oversaw both procedures, or at least that clay did not, in most cases, travel far to reach the artisan.

SOURCES OF LEAD

Lead-bearing ores occurred widely throughout the ancient Mediterranean and adjacent regions, though whether these deposits were exploited by the ancients is not always possible to detect. Attempts to map early lead sources are generally restricted to galena deposits, since those are the most abundant, easiest to smelt, and often contain significant amounts of silver. Evidence is usually based on a combination of modern geological surveys, ancient textual references, archaeological excavation and, beginning in the late 1960s, lead isotope analysis. There are only a few references in ancient literary texts to lead sources, primarily from the Roman period, but many earlier writers make reference to sources of silver, so these citations are often used to suggest possible lead origins. Since silver sources are not necessarily coincident with lead-bearing ores,[275] there are also logistical issues, to be discussed below, which may have prevented certain areas from producing commercial lead along with silver. Very detailed accounts have been published, which consider individual lead deposits by region and the evidence for ancient workings in those areas.[276] This information will not be reproduced here, but has been summarized in Figure 3.1. It is important to keep in mind that most of these sources were exploited on a small scale to fill local need, but far fewer were in a position to supply the growing urban centers of the ancient Mediterranean.

Since most synopses of ancient ore sources are regionally-based, it is easy to lose sight of chronological trends in resource exploitation. For this reason, I have separated the discussion of lead sources by time period. Some sources were exploited throughout several periods, others were worked and abandoned and sometimes reworked.

[275] Craddock (1995, 213) believes that the earliest exploitation of silver focused primarily on oxidized ores such as jarosite, based on evidence from Laurion, Rio Tinto, Tharsis, and Rajasthan, but still believes galena to have been the main source of lead.

[276] Still one of the most comprehensive works on ancient mining in Europe is Davies 1935, though he focuses on the Roman period. Forbes (1950, 183-201) provides a detailed diachronic review of the evidence with particular focus on the Near East. Nriagu (1983, 103-199) provides the most recent synthesis of lead sources throughout the world.

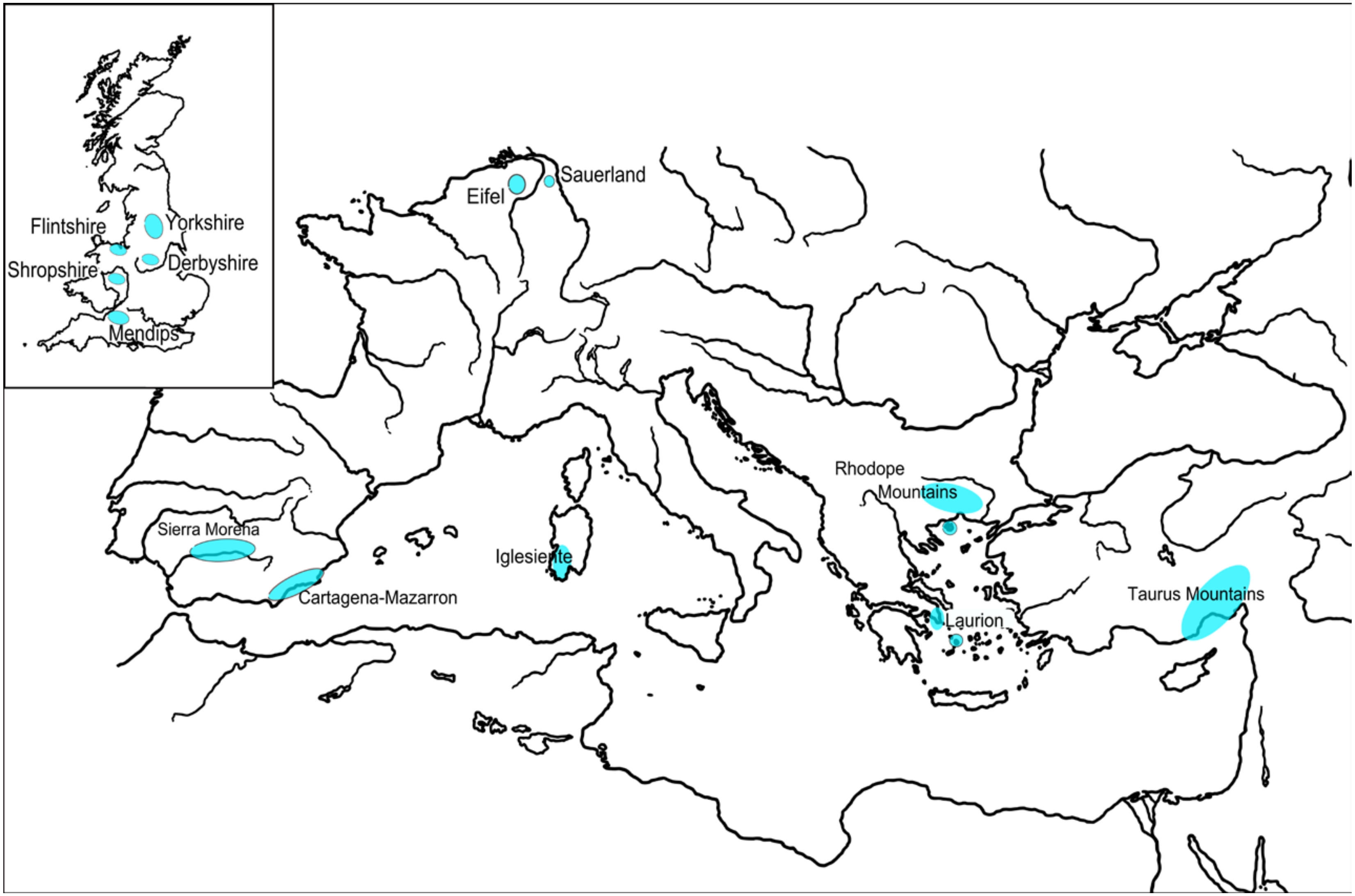

Fig. 3.1. Important lead ore bodies exploited in ancient times.

Chronology is often hard to determine, for two main reasons. First, evidence for ancient mining is often destroyed by subsequent mining efforts, thus the earliest date of exploitation can be easily underestimated. The lack of ancient archaeological evidence at a mine site, therefore, is by no means proof that those deposits were not worked in a prior period. The second issue is an archaeological bias for “earliest” milestones. Many research efforts focus on finding the oldest examples of mining or other resource exploitation in a region, and, as a result, evidence of later working may remain ignored or unpublished as it does not fit in with the research design of the project.

These limitations are overcome somewhat by evidence from lead isotope analysis. This technique compares the ratios of four stable lead isotopes (^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb) found in lead-bearing minerals to discern a distinctive isotopic signature of the ore body or bodies in the region. That same signature is not destroyed by the various processing stages, and therefore remains unchanged in slags left over from smelting as well as in metals derived from that ore.[277] Thus, in some cases well-dated artifacts can be traced back to certain ore bodies, indicating exploitation must have taken place at that time despite lack of direct archaeological evidence from the mining area.

Lead isotope evidence is dependent on a robust database of ratios from ores taken from a range of mining districts.[278] Due to modern political issues, many areas whence ancient lead ores may have originated are not currently accessible for sampling. Iran, Iraq and Afghanistan have a great deal of natural resources that likely supplied ancient societies, but their ore bodies have not yet been well classified. Even countries such as Egypt can be reluctant to allow researchers access to such data.[279] In some cases, one can only determine that a group of artifacts came from the same source, without learning the source location itself.[280] Additional difficulties arise when ore from more than one source have been mixed together in one artifact. There are statistical methods for

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[277] Gale 1978, 530.
[278] A minimum of 20 samples per source group has been suggested, but Yener et al. (1991, 551-2) believe that statistically valid results can be extracted from smaller sample sizes.
[279] Shortland 2006, 658.
[280] It is important to note that some ore bodies have overlapping signatures, and that any identification of origin is only considered statistically likely rather than hard truth.

inferring possible sources for the component ores, but the results are more tenuous than for undiluted metals.[281] For this reason, many researchers opt not to test lead artifacts, though the many Bronze Age and Iron Age lead objects tested by Stos-Gale and Gale have proved remarkably singular in their origins.[282] Despite these limitations, isotopic analysis can be a useful tool for revealing ancient lead production and distribution patterns.

Bronze Age

Despite the widespread distribution of lead ores, several important loci of Bronze Age civilizations – Mesopotamia, the Levant and Cyprus – are almost completely lacking in deposits. Archaeological finds have shown that lead objects were produced in Bronze Age Mesopotamia, but the raw lead from which they derived must have been imported. One must look northward for the likely source of lead supply for the ancient empires of the Near East.

Some of the earliest evidence for cupellation of silver using lead comes from the eastern Taurus mountains in highlands where the Tigris and Euphrates originate. Sites such as Fatmalı-Kalecik and Arslantepe in eastern Turkey have preserved silver-lead slag and litharge from early 4th millennium B.C.E. contexts.[283] The ore is presumed to have come from the nearby Keban, a region known to have been exploited at least from the Early Bronze Age.[284] How widely this metal was distributed during the Bronze Age has not been well documented using lead isotope analysis. This region was convenient to river transport, however, as discussed below, and so may have been a preferred source of lead in certain periods.

The central Taurus mountains, well to the west of the sites discussed above, offer another rich source of ore. Hemmed in by mountains, this area of Anatolia is difficult to

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[281] Stos-Gale 2000, 58.
[282] Ingots are usually considered "fresh" from single a mine, and thus are more likely to be tested. For examples of isotopic testing on a variety of lead objects, see Stos-Gale and Gale 1982, Gale et al. 1984, Stos-Gale and Gale 1994, Stos-Gale 2000, and Stos-Gale 2001.
[283] Hess et al. 1998, 57-9.
[284] Hess et al. 1998, 58.

access, but it has a corridor south to the Mediterranean coast through the Cilician Gates. The region was an important supplier of obsidian to the east during the Neolithic period.[285] Metals most likely continued to be exported from this region along established obsidian routes, presumably by sea from sites such as Tarsus. While this region has been studied most intensively for its evidence of tin production, lead isotope studies have linked a few Late Bronze Age lead artifacts to mines in this area, including a lead plaque from Assyria and two fish-net weights from the Uluburun shipwreck.[286]

The site of Habuba Kabira-South in Syria, several hundred kilometers to the south of Keban on the banks of the Euphrates, offers interesting evidence for lead sources. Dated to ca. 3300 B.C.E., this site contained evidence that argentiferous lead ore was being processed into metallic silver there.[287] Lacking local plumbiferous deposits, it is easy to assume that the ore simply came down from upriver; however, lead isotope analysis of samples of lead and litharge are consistent with two regions in the central Taurus Mountains.[288] The site itself was only active for approximately 150 years, and appears to have been part of a short-lived Mediterranean-oriented trade route that was apparently cut off by nomadic groups.[289] It does show, however, that in some periods, more distant sources may have been preferred to closer ones based on political situations and transportation factors.

Further west, there are several sources of argentiferous lead ores in the Troad as well as further south in Asia Minor in the region of Sardis in ancient Lydia. There is some evidence that these were exploited to some extent in the Bronze Age, but overlapping isotopic signatures have made it difficult to determine to what extent metals

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[285] Friedman 2000, 44-5.
[286] Yener et al. 1991, 572-575. Of the samples from the Aegean most were found to be consistent with one of the Taurus signatures (Taurus 2B), but this signature has significant overlap with ores from the Aegean islands of Anaphi, Kythnos, and Seriphos (Yener et al. 1991, 553), which seems a more likely source.
[287] Pernicka et al. 1998, 132.
[288] Pernicka et al. 1998, 130. A metallic lead sample fell into the range of the Taurus 1A group defined by Yener et al. (1991) linked with the Bolkardağ mining district, while several litharge samples were most similar to the underrepresented group from Esendemirtepe, just to the north (Pernicka et al. 1998, Fig. 4).
[289] Pernicka et al. 1998, 124.

from these regions were exported.[290] These western Anatolian lead sources may have been important locally, but there is little evidence of the output traveling far afield.[291]

In the Aegean, the most important lead sources are traditionally believed to have been Laurion in Attica, the Cycladic islands of Siphnos and Thasos, and Macedonia and Thrace.[292] Lead isotope evidence suggests that Laurion and Siphnos supplied most of the lead circulating in the Early and Middle Bronze Age, with a shift toward Laurion in the Late Bronze Age.[293] Siphnian sources have been linked to the Naxos boat models, suggesting that exploitation was under way here at least by the mid-third millennium B.C.E.[294] Gale points out that an Egyptian silver sample from Dynasty 11 was traced to Laurion, suggesting exploitation there as early as 2133-2000 B.C.E.[295]

Sardinia was also an active metal-producing region in the Bronze Age. Known primarily for its copper, the island nevertheless possessed rich deposits of argentiferous lead ores, particularly in the Iglesiente region of the southwest. Modern galena samples from the area have yielded as much as 0.15% silver, making them well worth exploitation by ancient standards.[296] Lead objects dating back to at least the Late Bronze Age and possibly earlier have been found on the island.[297] In addition to local use, some Sardinian lead appears to have been exported to Cyprus in this period. Cyprus is almost completely devoid of lead ores, and was dependent on imports. Lead isotope evidence

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[290] Sayre et al. (1992, 87-88) note that isotopic signature Troad 1 has significant overlap with both Taurus 1B and Kythnos 1 samples, and Troad 2 samples were consistent with an ore sample from Thrace. Stos-Gale (2000, 63) also points out that no significant Bronze Age smelting sites have yet been found in western Turkey.

[291] Based on lead isotope analysis of copper, silver, and lead ores and artifacts, Stos-Gale (2000, 66-68) notes an overall pattern in the Bronze Age Mediterranean of utilizing local metal sources as much as possible with very little importation.

[292] Gale (1980, 163) bases this identification primarily upon literary references, which are not as helpful for interpreting Bronze Age activity in this area. For a detailed map of ore deposits in the Aegean and Asia Minor, see Stos-Gale and Gale (1982, Fig. 5).

[293] Stos-Gale 2000, 63.

[294] Gale 1980, 192.

[295] Gale 1980, 177-8. The majority of artifacts cited in this study, however, date to the Late Bronze Age.

[296] Tylecote et al. 1983, 64.

[297] Tylecote et al. (1983, 66) cite evidence of lead pottery repairs dating to the Copper Age with no corresponding date range provided; based on context, it appears to be prior to the advent of the Nuragic period, ca. 1500 B.C.E. A fragment of a plano-convex copper/lead may be indicative of deliberately produced lead alloys in the Nuragic period; the low silver content of the lead suggests it may have been desilvered (Tylecote et al. 1983, 68). Lead seals and repairs from Late Bronze Age and Iron Age contexts are not uncommon in the region (Davies 1935, 69).

shows that some silver artifacts likely came from Laurion, but some bronze and lead items were primarily consistent with Sardinian ores.[298]

An interesting case for Bronze Age exploitation of lead is Egypt. There are reliable deposits of lead ore in the Eastern Desert, but it appears these were primarily exploited for raw galena and the ores were not refined until the Hellenistic or Roman period, the Egyptians relying on imported metallic lead for their needs.[299] The 18th Dynasty tribute records discussed in Chapter I suggest that metallic lead was being brought down from the northern kingdoms of Syria at least in the Late Bronze Age.[300] Stos-Gale notes that Bronze Age Egyptian silver artifacts tend to be isotopically consistent with ores from Laurion and Iran and presumes the Iranian supplies came to Egypt via overland routes along with other valuable items such as lapis lazuli from Afghanistan.[301] Iran is indeed rich in argentiferous lead ores, particularly in the Zagros and Alborz mountains, as well as the region between the cities of Kerman and Mashhad. As will be discussed below, it seems unlikely that valuable caravan space was taken up with lead, but waterborne export from these areas may have been viable either through the Diyala River to the Tigris, or even through the Persian Gulf to the Red Sea.[302]

Iron Age and Archaic Period

The principal Anatolian and Asian lead sources most likely continued to supply Mesopotamia during the Iron Age and Archaic periods. Textual evidence from Assyria

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[298] Stos-Gale (2000, 66), based in part on data published in Stos-Gale and Gale (1994). The silver artifacts tested in the 1994 study (212-214) are all from Pyla *Kokkinokremos*, while the lead artifacts were found in Ayia Paraskevi, Lapithos, Kition, Laxia tou Riou, Maa *Palaeokastro*, Pyla *Kokkinokremos* and Hala Sultan Tekke.

[299] Forbes 1964, 207-8. This idea has been supported by lead isotope analyses by Shortland (2006, 667-8), who notes Predynastic exploitation of many internal galena sources until the Middle Kingdom when Gebel Zeit, on the Red Sea coast, becomes the primary source of galena, yet no metallic lead artifact so far tested has matched any of these sources and all are presumed to be imported. If their primary need for lead was for cupellation, they may have been able to function efficiently enough using indigenous raw galena, thus saving fuel costs by eliminating a full refining cycle; however, no archaeological data as yet confirms this hypothesis.

[300] As mentioned above (supra n. 249), this evidence hinges on the original Egyptian term signifying lead and not tin.

[301] Stos-Gale 2001, 72.

[302] Nriagu 1983, 158.

suggests that silver was brought down from the Armenian Highlands, and thus may also have been an important source of lead.[303] In the Archaic Aegean, Laurion and, despite its relative absence from LBA contexts, Siphnos still predominate based on lead isotope analysis of lead and silver artifacts.[304] A study of three *Hacksilber* hoards using lead isotope analysis reveals that a variety of sources of silver were supplying the Mediterranean.[305] Samples from the site of Tel Miqne-Ekron in Israel, dated to the first half of the first millennium B.C.E., were consistent with ores from Laurion, Siphnos, and Chalkidiki. Three samples from the late sixth-century Selinus hoard from Sicily were consistent with the Aegean, and one with Iran. A third hoard, from Shechem in Israel, is not as securely dated; it was found below a Hellenistic floor, and thus has been given a date range of 1200-200 B.C.E. Seven samples from this hoard were consistent with samples from Iran, and three with Huelva in Spain. Clearly, a wide variety of sources were contributing to the supply of silver in the Mediterranean, although we cannot say if all of these regions exported refined lead as well.

The issue of when Spanish metals began to circulate beyond the Iberian Peninsula is much debated, though they most likely began to be shipped eastward as part of the Phoenician colonization period starting ca. 800 B.C.E.[306] Spain has significant deposits of argentiferous lead ores in the Sierra Cartagena in the southeast and the Sierra Morena in the south.[307] Several references in the Old Testament describe metals being imported to the east by the ships of Tarshish, though only one lists lead specifically. In Ezekiel,[308] the city of Tyre is singled out for its immense riches, and it is said to have traded goods to the people of Tarshish in exchange for silver, iron, tin, and lead. There is much debate over where this land was, and some have proposed that it refers to

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[303] Forbes (1964, 213) states that Mount Judi to the northeast of Ninevah is said to have supplied silver to the Assyrian kings Sargon II (721-705 B.C.E.) and Tukulti-Ninurta II (890-884 B.C.E.).

[304] For Archaic Siphnos, see Gale et al. (1984, 395). Gale (1980, 183-192) outlines the evidence for the demise of the Siphnos mines by the fifth century B.C.E., but notes Herodotus (3.57) describes Siphnos during the time of Polycrates (ca. 535-522 B.C.E.) as being very rich due to their gold and silver mines.

[305] Stos-Gale 2001. Data cited below come from pp. 61-2. Evidence from this period primarily comes from silver rather than lead and must therefore be used as a proxy.

[306] Local exploitation of lead can be traced back to the Bronze Age but appears to have been relatively rare (Domergue 1990, 101, 130).

[307] Domergue 1990, Fig. 4.

[308] Ez. 27:1-12.

Tartessos in Spain, while others propose a location further east.[309] Since the literary evidence is not certain, the Phoenician wreck at Mazarrón (**4**), dated to 650 B.C.E. may be earliest direct evidence of the exportation of Iberian lead products. This ship carried litharge rather than refined lead, showing that even though many early scholars dismissed this as a waste product, it had enough value to the ancients to transport it beyond the mining region.

Another Phoenician wreck, Bajo de la Campana A (**5**), north of Cartagena, carried a consignment of over a ton of lead ore. Dated to ca. 600 B.C.E., the ship carried a range of raw materials, which also included elephant tusks, tin, copper, and possibly pitch and minium.[310] The fact that they were exporting the ore is unusual and may suggest they intended to use it directly for cupellation without desilvering it first, since any silver would be recovered during the process and thus resources need not be wasted extracting it in advance before shipment. Both of these wrecks attest that lead production in Spain at that point was not standardized and that lead exports could take many forms.

Classical and Hellenistic

The predominant source of lead in the Classical period was Laurion in Attica. Literary sources abound with references to the silver of Laurion, especially the famous strike of 483 B.C.E., which provided the funds for Athens' great fleet of warships, but few authors make specific reference to lead. Archaeological evidence, including ingots from mining areas, attests to the active production of refined lead.[311] Access to the mines was periodically cut off during the Persian and Peloponnesian wars, but the ores

[309] All the metals listed in the citation were available in Spain, though the same can be said for the Italian region of Tuscany, which was being exploited by the Etruscans at the time, and which Davies (1935, 67) offers as an alternative interpretation for the location of Tarshish. Aubet (2001, 204-6) believes the meaning of Tarshish changed over the centuries and originally referred to a location in the Red Sea; she also notes that early classical authors believed it referred to Tarsus in Cilicia. See Domergue (1990, 7, 141-44) for a detailed review of references to Tartessos and their interpretation. It is interesting to note that neither gold nor copper are included in the list in Ezekiel, both of which are abundant in the Iberian peninsula. In other verses (Jeremiah 10:9, Isaiah 60:9; 2 Chronicles 9:21; 1 Kings 10:22), Tarshish is mentioned without specific reference to lead, but rather in reference to gold, silver and other, non-metallic luxury goods. Thus, it is possible that this place name may have ultimately functioned as a narrative trope indicative of any faraway land of great wealth.

[310] Polzer and Pinedo Reyes 2010, 3-4.

[311] Conophagos 1980, 332.

themselves remained viable in this period. Herodotus also mentions Siphnos, Thrace, Lake Prasiad, and the Pangaean Mountains in Macedonia, as having silver mines.[312] The extent to which any of these areas besides Laurion contributed to the regional or extra-regional supply of lead is not known.

The output of Laurion began to wane significantly in the Hellenistic period.[313] With the reign of Alexander the Great, the coinage of Macedonia took precedence in the region, shifting the center of silver production northward.[314] Conophagos points out that much of Alexander's initial coin issues came from plundered metals from the Near East, but local ores must eventually have supplemented or supplanted this source.[315] Polybius, for instance, tells us that in 227/6 B.C.E. Chyrseis, the wife of Antigonus Doson of Macedonia, donated 3,000 talents of lead to Rhodes after a disastrous earthquake.[316] None of the other regions giving aid was listed as providing lead.

Perhaps due to the relative abundance of textual data, lead isotope analysis has not been as frequently applied to artifacts from these two periods.[317] Coins are the focus of most isotopic studies, and these tend to concentrate on the sources of copper.[318] Several lead artifacts from shipwrecks, such as anchors and sheathing, have been isotopically tested to help learn more about the ship's origin. Lead samples from the

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[312] Hdt. 7.144, 3.57, 5.23, 5.17, 7.112. The mines at Siphnos flooded early in the Classical period, and thus was no longer a significant source of lead or silver (Gale 1980, 183).
[313] The latest mine concession yet found from Athens dates to 307 B.C.E. (Conophagos 1980, 120).
[314] Conophagos 1980, 119.
[315] Conophagos 1980, 120.
[316] Polyb. *HN* 5.89.7. Despite having no indigenous lead ore, Rhodes was known by the early fourth century for its slingers who used lead shot (Xen. 3.3.16-7) rather than stone. In the first century BCE, Vitruvius (7.12.1) describes the Rhodian procedure for manufacturing white lead from metallic lead, for which the island still had an excellent reputation a century later (Plin HN 34.175; also noted in Dioscorides (3.96); Atkinson (1949, 77) believes the common source for this was the early first century C.E. King Juba II of Mauretania). The fact that Rhodes was renowned for two separate lead-related practices indicates the importance of the metal to the island. With Rhodes the dominant port in the Greek islands during the Hellenistic period, lead may have become a necessity for equipping and repairing ships. It is thus possible that the maritime importance of lead, arising in the late Archaic period, may have led to securing imports of the metal, perhaps from Athens, and thus subsidiary lead industries developed. The full list of items donated by the ruling couple of Macedonia, which also includes such vital shipbuilding supplies as timber, iron and pitch, supports this possibility.
[317] With the increase in lead use during this period, the likelihood of mixing is increased, which also makes researchers reluctant to invest limited funds in expensive testing that may yield results of little value.
[318] For example, Attanasio et al. 2001.

early third-century B.C.E. Kyrenia wreck were all consistent with Laurion ores.[319] Lead from the anchor cores from the Classical wreck at Tektaş Burnu were sourced to Laurion, though the lead bolt from one ophthalmos was consistent with the Balya mine in the Troad.[320]

Near Eastern regions were likely less dependent upon Aegean sources in the Classical period, as they were politically at odds with Greece until the time of Alexander. They may have continued to utilize traditional sources in the Taurus and Zagros mountains, though specific data are difficult to find. Iberian sources may have continued to be significant, despite the fall of the Phoenician homeland to the Persians in the sixth century B.C.E., leaving Carthage to control the vast trade network of the western Mediterranean. Even though Spain is rarely mentioned in literary texts of the period, which are predominantly Greek, other evidence points to an increasing output of lead ore from the region. Greenland ice-core data point to significant levels of anthropogenic lead in the atmosphere starting after 680 B.C.E., and samples dated between 366 B.C.E. and 220 C.E. show a possible correlation with lead isotope signatures from a combination of several Spanish sources.[321] This is supported by archaeological evidence, such as *defixiones* with Iberian lettering appearing as far east as the Levant.[322] Pliny reports that many of the mines worked by the Romans were originally opened by the Carthaginians and were still referred to by their Punic names.[323]

Roman Period

The mineral wealth of Tuscany, utilized by the Etruscans, did not play an important role in Roman metal acquisition. In part due to a decree of the Senate

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[319] Susan Katzev, pers. comm. 2008.
[320] Deborah Carlson, pers. comm. 2008. This raises the question of whether the ship might have been built in Asia Minor rather than mainland Greece, since *ophthalmoi* are more integral to the ship, while anchors are more portable and frequently replaced.
[321] Rosman et al. 1997, 3415. The study showed increasing lead pollution starting ca. 680 B.C.E., but no isotopically traceable samples were available prior to the fourth century B.C.E.
[322] Domergue 1990, 158.
[323] Plin. *HN* 33.96. Diodorus Siculus (5.38.2) also credits the Carthaginians (and their greed) for opening the majority of the mines of Spain.

prohibiting mining there,[324] Strabo also suggests that in light of abundant external sources brought under Roman control, the Italian ores were not worth exploiting.[325] Between wresting control of the Iberian Peninsula from the Carthaginians and the gradual acquisition of the city-states of Greece over the course of the second century B.C.E., Rome found itself in control of the two most widely-circulating sources of lead in the ancient world – Spain and Laurion. Although fresh output at Laurion essentially ceased by the end of the second century B.C.E., the improved technical efficiency of Roman metallurgists allowed them to reprocess the considerable slag piles left by previous generations of miners to extract more silver.[326] Some lead may also have been refined as part of this operation.

In Spain, the Romans began gaining control of the southeast, particularly the argentiferous lead deposits of the Cartagena-Mazarrón region, after the defeat of the Carthaginians by Scipio Africanus in 206 B.C.E.[327] Despite nominal political control of the regions of the southwest by the mid-second century B.C.E., it does not appear there was enough internal stability for significant exploitation of the mines of the Sierra Morena until the end of that century.[328] As in earlier periods, more attention in ancient texts is paid to silver production. For example, Polybius, in the second century B.C.E., remarked on the size of the silver mines of Carthago Nova (modern Cartagena) but makes no mention of lead.[329] The many references to Spanish lead in Pliny several centuries later shows the increased importance of lead in its own right and the geographical extent of exploitation.[330] The majority of lead ingots found from the Roman period can be traced back to Spanish sources, with the earliest coming from

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[324] Plin. *HN* 3.24. Some believe this law was passed out of fear of slave revolts, (Rickard (1932, 408) credits Theodor Mommsen for the original idea); Humphrey et al. (1998, 174) suggest it was a move to protect mining interests in Spain.
[325] Strabo 5.1.12.
[326] Conophagos 1980, 123, citing Diod. Sic. 34.2.19 and Ath. 6.272e-f. Isotopic analysis of Athenian coins from the second century B.C.E. shows Laurion silver was being used (Gale 1980, Fig. 7).
[327] Domergue 1990, 181.
[328] Domergue 1990, 184-5.
[329] Strabo 3.2.10 citing Polybius, who states that the town housed 40,000 people involved in the production of government silver.
[330] Pliny *HN* 34.158, 34.164, 3.30, 4.112, 34.95, 33.106 (on litharge).

Cartagena-Mazarrón in the early first century B.C.E., with a shift to Sierra Morena evident in the first century C.E.

Over the course of the second and first centuries B.C.E. a large number of Romans sought their fortunes in the rich mineral resources of the Iberian peninsula, which included gold, silver, copper, tin, iron, and even mercury. Such abundance allowed for a concentration of mining infrastructure in one region, leading in some cases to the abandonment of viable mines in other areas such as Gaul and Sardinia.[331]

The local exploitation of lead in frontier regions, however, continued and even intensified in some areas despite the overwhelming output from Spain. Roman expansion carried in its wake an unprecedented demand for lead into areas previously content with minor, local use of the metal. With construction of new villas, towns, and military forts, the Romans utilized lead in ways and amounts unprecedented in these newly conquered territories. As the frontier penetrated further and further from the Iberian peninsula, local mines were called upon to satisfy the growing regional need.

For example, lead isotope analysis was performed on a group of Roman artifacts from Germany dated between 15 B.C.E. and 400 C.E. The earliest artifacts show sources consistent with the Eifel deposits of central Germany and the Massif Central of France; from the early first century C.E., the lead is almost exclusively from Eifel, with British lead appearing after the first century C.E. and bolstering local supplies in the third and fourth centuries C.E.[332]

Of the northwestern regions of the Empire, it appears primarily Britain had sources of lead abundant enough for extra-regional export.[333] It may be that their relatively low silver content had been a disincentive for exploitation until the Romans

[331] Davies notes several instances of this phenomenon, such as the lead-silver mines in Sardinia (1935, 70) and tin mines in France (1935, 84), where evidence for mine operation disappears during the early Empire but resumes again in the late Empire.
[332] Durali-Mueller 2007, 1565-6.
[333] Recent research on the ingots from the Saintes-Maries-de-la-Mer 1 wreck (**60**) indicates that they were derived from German ores; some suggest the Rena Maiore (**46**) cargo also originated from Germany (see Appendix B).

arrived with their increased demand for the utilitarian metal.[334] Exploitation by the Romans may have begun in 49 C.E., soon after their conquest of that territory, starting in the Mendips Hills (Somersetshire).[335] The majority of datable ingots found in Britain, however, begin with the Flavian Dynasty (ca. 70 C.E.), with finds from Flintshire, Yorkshire, Shropshire, and Derbyshire.[336] By the late first century C.E., Spanish lead was rapidly being replaced by lead from these sources. Pliny, writing in the third quarter of the first century C.E., attests to the period of transition, stating: "Black lead which we use to make pipes and sheets is excavated with great effort in Spain and through all of Gaul, but in Britain it is found so widely on the very surface of the earth that there is a law prohibiting the production of more than a certain amount."[337] How long such a law remained in effect is unknown, but, at present, the latest known shipwreck carrying Spanish lead ingots dates to the reign of Vespasian.[338] As production shifted northward to supply the occupying forces of Britain, Gaul, and Germany, there appears to have been concomitant exploitation of sources closer to Rome, particularly those of Sardinia, to fill Italian demand.[339]

Little is known of supplies in the eastern Empire at this time, though the mines of Egypt did come under more intensive exploitation in this period. References in Pliny and

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[334] Despite Tacitus' claim (*Agr.* 12.6) that Britain had gold and silver, there is little else to suggest that silver was a significant resource in Britain. In the *Gallic Wars*, Caesar briefly comments on the metals of Britain, noting their use of copper, gold, and iron for currency, then notes that tin and iron can be found there but not copper (Caesar *B. Gall.* 5.12.4: "*nascitur ibi plumbum album in mediterraneis regionibus, in maritmis ferrum, sed eius exigua est copia; aere utuntur importato.*"). There is no mention of silver or lead, which is plentiful in Britain and was most likely being exploited by local populations by this time. It is clear from Caesar's statement that lead was not yet considered a resource worthy of economic or strategic note.

[335] An ingot dated to Tiberius and one to the consulship of Veranius and Pompeius (49 C.E.) were discovered in Somerset (*RIB* 2404.1 [*CIL* vii 1201] and 2404.2 [*CIL* vii 1202]); the former, discovered in 1544 and now lost, may have been a commemorative plaque, and some doubt has been cast on the interpretation of latter's inscription (Whittick 1982, 116-17).

[336] Nriagu (1983, 106) provides a summary of ingot finds by region; a detailed list can be found in Tylecote 1986, Tables 38 and 39.

[337] Plin. *HN* 34.164: "*Nigro plumbo ad fistulas lamnasque utimur laboriosius in Hispania eruta totasque per Gallias, sed in Britannia summo terrae corio adeo large, ut lex interdicat ut ne plus certo modo fiat.*"

[338] See the Ses Salines wreck (**56**) in Appendix A.

[339] An ingot bearing the name Hadrian suggests the second century C.E. for the beginning of this shift (Davies 1935, 70). This ingot was linked by lead isotope analysis to deposits from the Iglesiente district of Sardinia (Pinarelli et al. 1995, 84-5). Literary references to Sardinian lead-silver mines begin appearing in the third century C.E. and continue through the fifth century C.E. (Nriagu 1983, 123-4, citing the *Philosphumena*, the *Codex Theodosianus* 9.7.7, 10.9.6 and 10.9.9 and Sidonius Appolinaris (8.49)).

the *Periplus Maris Erythraei* indicate that Rome exported some lead through Egypt to India in the first and second centuries C.E., though whether this was derived from eastern or western sources is not explicitly stated.[340] Several ingots from the Imperial period discovered at Caesarea (**59**) appear to have been derived from Macedonian sources, though how much lead was produced there in this period has not been adequately studied.[341] With Laurion effectively abandoned by the early Empire, supplies from Spain may have supplemented traditional eastern sources.[342] The previously-mentioned Mljet wreck off the coast of Croatia carried a cargo of lead-based minerals, which excavators believe originated in the area around modern Srebrenica (Bosnia and Herzegovina).[343] While it is assumed that this cargo was destined for Italy, similar shipments may also have made their way east from the Adriatic.

MINING

Little is said in ancient literary sources about mining techniques until the Roman period, but surviving ancient mine workings from the Bronze Age and even earlier have revealed much about the development of mining. At first, surface deposits were exploited, with digging efforts following veins downwards or sideways as far as was practicable, either in shallow pits or wide, exposed depressions called opencasts.[344] Shaft mining appears later in the Bronze Age, generally characterized by closely-spaced shafts, minimal organization of shaft placement, and no systematic ventilation or drainage.[345]

Advancements in organization and technology become evident in the first millennium B.C.E. Up to this point, the two major limitations on mining were the

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[340] Plin. *HN* 34.163; *Peripl. M. Eryth.* 49, 56. It must be noted that the Pliny reference comes immediately after a discussion of *plumbum album* (tin), so it is not clear whether he means both types of *plumbum* (lead and tin) in this case, or just tin.

[341] Davies (1935, 226-7) believed that Macedonian ores were insignificant to the Romans, but the finds from Caesarea (Raban 1999) are challenging this conclusion.

[342] There is much discussion of what the great grain ships supplying Rome carried back with them to Egypt. There is no direct evidence that lead helped fill their holds, but it is a possibility, its density providing ideal ballast. Isotopic studies of Roman artifacts from Egypt may prove interesting.

[343] Radić and Jurišić 1993, 122.

[344] Craddock (1995, 31) estimates that early pit mines tended to be no deeper than 10 m.

[345] Craddock 1995, 63, 69.

collection of deadly fumes in the shafts, and the level of the water table.[346] It is possible that the close spacing of early shafts helped improve the air quality, and the use of controlled fires to create drafts was also likely employed in early shaft mines.[347] Mines from the first millennium show evidence of greater planning and engineering,[348] perhaps with ventilation in mind. The lengthy tunnel systems found at mines at Siphnos and Laurion indicate that ventilation issues were well under control at least by the early Classical period.[349] Pliny reports the use of cloth fans at the mine face in Spanish gold mines,[350] but as these do not survive archaeologically, it is difficult to know how early this technique developed.

The ability to dig longer tunnels and shafts led to the need for support systems. These were primarily in the form of wood, piles of waste stone or simply unexcavated pillars. By modern standards ancient galleries were relatively narrow, perhaps in order to minimize time taken to drive the shafts,[351] limiting, to some extent, the amount of supports required, but still requiring a steady supply of material. The need for wood to fuel smelting processes most likely took precedence over safe mine conditions; however, when wood was in short supply, dry stone supports could be used.[352]

These widespread tunnel systems were more likely to run deep enough to encounter the water table. Where the geomorphology permitted, water from springs and

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[346] In addition to fumes coming from the minerals themselves, smoke from lamps and also from firesetting added to the problem. Firesetting is a technique used to speed excavation by building up a fire against the rock face resulting in cracked, brittle stone which can then be easily broken up with hammers. Craddock (1995, 33) reports a penetration into the rock face of 30 cm based on experiments conducted with a fire left to burn overnight.

[347] Craddock 1995, 63.

[348] Craddock 1995, 69.

[349] This assumes that the systems found at Siphnos represent the most recent workings, abandoned once flooding started some time after the reign of Polycrates (ca. 535 - 522 B.C.E.).

[350] Plin. *HN* 31.49.

[351] Davies (1935, 20, 261) reports galleries at Laurion which were 2-3 feet wide by 2-2.5 feet (0.6-0.9 m x 0.6-0.8 m) and adits at Kapsalos, Siphnos as 3 feet high by 2 feet wide (0.9 m x 0.6 m).

[352] Davies (1935, 23). Use of stone supports generally required a change in the gallery shape from square to arched, perhaps adding somewhat to the time taken in driving shafts. Some evidence that stone supports were used in Laurion comes from Plutarch (*Mor.* 843d) who reports that Lycurgus convicted Diphilus of removing the supports of the silver mine he was working and thereby enriching himself. Proper maintenance of timber supports was required by Roman law according to the Vipasca tablets from Spain, which most likely date to 173 C.E., though 146 C.E. and 235 C.E. are also possible (Edmondson 1989, 97).

other running sources could be diverted or channeled out, and systems of hand-bailing were also employed.[353] Surpassing the water table, however, generally required raising water above its natural level at a rate faster than it could accumulate. The demise of the mines of Siphnos due to flooding, mentioned above, indicates that this was still a significant problem in the Classical period. At the Spanish mine of Baebalo, Hannibal reportedly tackled this problem using a series of watermen all along the 1500-*passus* (2.2-km) shaft to bail out the mine.[354] The Romans, however, pioneered the application of mechanical assistance in water removal. Adits, pumps, Archimedean screws, and waterwheels have all been attested in surviving Roman mines in Spain such as Sotiel Coronada, Sierra de Cartagena, Tharsis, and Rio Tinto.[355] The mine system at Rio Tinto had a significant water-wheel system as well as drainage adits that stretched up to three kilometers.[356]

Once extracted, the ore needed to be crushed and washed to separate out the waste rock before smelting.[357] Archaeological evidence from sites in the region of Laurion reveals a system of work areas (*ergasteria*) with rooms for crushing and milling, tanks and tables for washing and drying the ores, and a series of channels linking the tanks together.[358] An operation on the scale of Laurion required many such installations, and at least a dozen have been found at Thorikos alone.[359] Such areas required

[353] Nriagu 1983, 83.
[354] Plin. *NH* 33.97.
[355] Domergue 1990, 440-60. Craddock (1995, 81), following Healy (1978, 100), believes that the few pumps that have been found were too small for serious drainage, and were used for domestic water needs; Domergue (1990, 456-9), however, provides a more thoughtful analysis of the two primary examples, a bronze pump from Sotiel Coronado and a lead pump from Sierra Cartagena, the latter of which clearly functioned as mine drainage. A pump of wood was found in a Roman mine in Bulgaria (Domergue 1990, 458). Archimedean screws were specifically mentioned by Diodorus Siculus (5.37.3) as being used in Spain, and several have been found in mines at Sotiel Coronado, Santa Barbara, and El Cententillo, though those from the latter two have since been lost (Domergue 1990, 450).
[356] Craddock 1995, 77. The long adit was reportedly even rehabilitated for use by miners in the nineteenth century (Craddock, citing Salkfield 1987, 10, 40).
[357] Conophagos (1980, 127) states that at Laurion ore containing over 30% lead went straight to the furnace, and did not require concentrating via crushing and washing. He also notes that minerals with less than 7% lead would be discarded altogether.
[358] Jones 1982, 174-7. Sites in the region include Thorikos, Soureza, and Agrileza.
[359] Conophagos 1980, 391.

investment in construction as well as a reliable source of water. In regions with little water, such as Laurion, rainwater was carefully collected and recycled.[360]

After the ore was prepared, it was ready for smelting. Jones notes, based on evidence from Laurion, that "because of the noxious fumes emitted, and the need to have good supplies of fuel at hand, the main smelteries were probably fewer in number and set apart from the *ergasteria*."[361] The ore could be processed initially in a standard furnace, resulting in what is called "crude lead" or *werkblei*, a concentrated lead/silver mixture, which would then be processed to extract the silver by cupellation.[362] This left the lead in the form of litharge, which would require further processing to convert to metallic lead, though ore with silver content too low for extraction was sometimes smelted directly into lead. [363] With up to four separate heating phases, the demand for fuel must have been exceedingly high.

Overall, mining involved a heavy investment in resources such as water, charcoal and timber, as well as the construction of facilities and roads, and, most importantly, labor. Despite the many labor-saving devices utilized by the Romans, human effort was always the primary means of extracting and processing the ores. It was difficult and dangerous work, especially once shaft mines grew more extensive. The rock face was broken up with hammers and picks; ore was then carried out of the tunnels in bags, baskets or trays,[364] at which point crushing, washing and smelting took place. The latter duties could be relegated to weaker workers, such as older men, children and women, but strong men were required for the main digging.[365] Death from fumes and

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[360] Jones 1982, 177.
[361] Jones 1982, 182.
[362] If galena was being smelted, there must also have been an initial roasting phase at a low temperature to convert the sulfide to an oxide; however, this could be performed in the same furnace and smelting could follow directly on without interruption (Forbes 1964, 227-8).
[363] This is especially likely for Bronze Age mines where the estimated limit for silver extraction was in the range of 800 ppm for the EBA, 400-600 ppm for MBA and LBA, 200 ppm for Classical Greece (Stos-Gale and Gale 1982, 484), and 100 ppm in the Roman Empire (Pernicka et al. 1998, 129). Lead artifacts from Mycenaean Greece, for instance, appear to have been made from lead that was not desilvered (Stos-Gale and Gale 1982, 485).
[364] For archaeological examples see Craddock 1995, 81-2 and Forbes 1964, 207-9.
[365] As described by Diodorus Siculus (3.12.1-2).

cave-ins were common and it is easy to imagine that it was not a highly sought-after occupation.

Much, indeed, is made of the slave labor utilized by the Greeks and Romans. The larger operations such as those in Spain and Laurion clearly depended upon it in the Classical and Roman periods. Diodorus Siculus offers a dire description of slaves in the gold mines of Egypt, and Strabo says the arsenic mines of Mount Sandaracurgium near the Black Sea were worked by those condemned to slavery for their crimes.[366]

Other methods of mine working were possible, however, especially in the earlier periods where deposits were more abundant at surface levels and located far from central governments. In many cases, trade and tribute, rather than direct domination, were the main methods for acquiring distant resources. How the local cultures supplying that demand were organized is difficult to tell from the archaeological record. Rovira contests the notion of dedicated metallurgical communities in Chalcolithic and Bronze Age Iberia, suggesting instead, in relation to copper, that farming and cattle were still the primary economic modes of the indigenous communities, with metallurgy a secondary activity.[367] Acquisition of minerals in this model is presumed to have been carried out by the farmers and herders on an as-needed or possibly seasonal basis.[368] As demand for export increased, specialists may have emerged who dedicated a majority of their time to the extraction of metal ores. We can only speculate whether such specialists were independent prospectors or compelled labor.

It is nearly impossible to detect free and slave status in the archaeological record. Kassianidou and Knapp note that isolated mining communities tend to tie into broader trade networks, and the resulting changes in society are visible in the archaeological record, often with an increase in the visibility of hierarchical organization.[369] This implies control by certain powerful individuals (or families) over poorer inhabitants who

[366] Diod. Sic. 3.12-13.3; Strabo 12.3.40.
[367] Rovira 2002, 6. The relative simplicity of copper technology is in part credited for the lack of specialized communities, and the same is true for lead, though not, perhaps, for silver. The early lead finds from Anatolia may also represent non-specialized, local use rather than an extensive trade network.
[368] On the idea of seasonal exploitation by agriculturalists, see Kassianidiou and Knapp (2005, 236) and the works cited therein.
[369] Kassianidou and Knapp 2005, 230-1.

provide labor for mining and processing. Thus, limited metal production for local use may have taken a much different form than that for long-distance trade.

Hints of other modes of labor can be found in the historical record. At least one inscription, dating to 164 C.E., attests to a free citizen contracting to work in the gold mines of Dacia.[370] This type of labor may have been too expensive for lead mines to support without a significant concomitant abundance of silver. Slave labor was not always available, however, so free contract labor must be considered a possibility when attempting to reconstruct ancient mining systems. Tacitus makes reference to a Roman military commander who ordered his soldiers to mine silver in Germany in the first century C.E.[371] Reportedly, the effort was not profitable and was soon abandoned, but in times of need, military forces may have been utilized for mining, especially in frontier situations.

TRANSPORTATION

The issue of transportation is an important aspect of the economy of any mining operation, but lead production, with its low margins, would have been particularly dependent upon minimizing costs in that regard. It is generally accepted that water transport, with its capacity for bulk transport, was more economical.[372] While it is easy to treat land and sea transport as separate and opposing forces, Laurence's observation that the transport of grain in the Roman empire "involved a complementary system of land, river, and sea voyages"[373] is also widely applicable to metal transport throughout the ages.

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[370] *CIL* III, 948 (Dacicae X).
[371] Tac. *Ann.* 11.20.
[372] Much of the hard data to support this comes from Roman sources, primarily Cato's discussion of the transport of a mill to his estate in the second century B.C.E. (*De Ag.* 22.3) and the maximum prices listed in Diocletian's price edict of 301 C.E. (cf. Yeo 1946; Duncan-Jones 1982, 7-8; Laurence 1998). The basic advantages of waterborne transportation also obtained for earlier periods, and may, indeed, have been even more pronounced in the absence of Roman road building endeavors. Duncan-Jones (1982, 368) calculated a cost ratio of land to river to sea transport during the Roman Empire of 1:4.9:34-42. Greene (1986, 40) points out that prices varied regionally based on local conditions (such as primitive roads or stronger currents), but the overall relationship of land transport being most expensive and sea transport being cheapest remains consistent.
[373] Laurence 1998, 134.

No mining operation could avoid a certain amount of land transport, though one presumes that there was an effort to minimize the portion of the journey consigned to land. Adits were located as close as possible to ore bodies to avoid unnecessary tunneling and, even in places like Laurion, were rarely located directly upon the seashore or riverbanks. Subsequent crushing and washing operations would ideally be located close to the mine heads to reduce the weight to move. If sufficient water could not be easily supplied to this area, ore would have to be transported to work areas either by wagon – where sufficient roads were available – or pack animal. Smelting itself could be a separate and even distant operation.[374] There is evidence to suggest that in some cases ore was moved to smelting operations located at the secondary production site.[375] The cost of transporting ore to a separate smelting site had to be balanced against the cost of transporting fuel to the extraction zone. In some cases fuel may have been a much more difficult resource to transport.[376] Simple topography was a primary consideration: moving several tons of ore downhill from a mountainous mine may have been much more practical than moving tons of wood or charcoal uphill or even upstream to a mine site. In early periods, furnaces were sometimes placed on hilltops to take advantage of prevailing winds to stoke the fire, further necessitating the transport of ore some distance from the extraction point.[377] In the case of lead ore, the ultimate end product had

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[374] Lo Schiavo et al. (1985, 317) describe a situation in which Nuragic copper (presumably in ore form) from the Sardinian mines at Funtana Raminosa might have been taken over a high pass rather than down the nearby valley, in order to exploit highland sources of kaolin, an ideal material for furnace lining.

[375] Several wrecks carrying ore, usually of either lead or iron, have been found from the Roman period (Parker 1992a, 18-9); the Bajo de la Campana wreck (**5**), discussed above, was carrying crushed (and possibly roasted) galena; Snodgrass (1980, 139-40) suggests this was common practice in Archaic Greece based on the discovery of iron smelting sites in proximity to forges yet distant from ore sources, but does not provide any lead-related examples. Pliny (*HN* 33.118) reports that cinnabar mined in Spain was, by law, transported to Rome for processing, but does not explain why. Elsewhere (*HN* 33.106) he mentions litharge was transported from Spain to Puteoli for processing. Tylecote (1992, 58) also feels that litharge was exported from Laurion for processing, due to fuel pressures.

[376] Davies (1935, 66) discusses the early exhaustion of fuel sources on Elba due to intensive iron working, with ores later imported to Populonia on the mainland, presumably rather than bringing fuel to Elba (citing *Mir. ausc.* 837 B 26; Varro *ap*. Servium *Aen*. X. 174). Early copper workings there may also have depleted fuel supplies.

[377] Kassianidou and Knapp (2005, 233) give the example of Chrysokamino, Crete, and note that this strategy generally dates to the Early Bronze Age. Craddock (1995, 209) points to examples of this strategy still being employed in Britain in the Middle Ages to protect local inhabitants from dangerous fumes.

additional influence on processing organization. Since the ratio of silver to lead is so extreme, often measured in grams per ton, if the lead was not to be used, it made little sense to transport ore a great distance for desilvering. If the lead had further use, then ore may indeed have been transported.

Land Transport

The most well-documented example of land-based metal transport in the Bronze Age is that of the Old Assyrian caravan routes through which Anatolian silver was traded for textiles and tin from Assyria in the early 2nd millennium B.C.E., described in the Kültepe tablets.[378] The association of lead with silver has caused some to conclude that lead in Mesopotamia entered through this route.[379] A closer examination of the evidence shows that lead is never mentioned in the tablets,[380] and that the heavy trade is primarily one-way. Donkey caravans transported tin and textiles 1200 km north into Anatolia, the donkeys were then sold and the traders returned southward with silver and sometimes gold.[381] It seems unlikely based on these records that significant quantities of lead, both extremely heavy and not yet in great demand, made its way south with returning caravan traders.[382] It is more likely that those sources closer to water routes were preferred for lead.

Many centuries later, the Romans also used land routes, at least in part, for tin. Diodorus relates that "much tin is brought over from the island of Britain to Gaul, which lies opposite, and is carried on horses by traders through the heartland of Celtica to the Massalians and to the city called Narbo.[383] The fact that this route is singled out, unlike those for other metals, implies that this was an unusual practice. Presumably, the rarity

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[378] The texts primarily cover trade between the two entrepôts of Kanesh and Assur, thus no information is available on transport between the extraction point and the trading centers.

[379] E.g. Nriagu (1983, 150). Forbes (1964, 218) bases his conclusion that the Assyrians shipped lead to Anatolia for desilvering on the old interpretation of *anaku* as lead.

[380] Based on published material in Larsen (1967 and Michel (2001); there are a significant number of tablets that have yet to be published, so references to lead may turn up in the future.

[381] Kuhrt 1998, 27.

[382] Larsen (1967, 178) suggests that even moving copper along this route might have been too unprofitable to attempt.

[383] Diod. Sic. 5.38.5; translation from Humphrey et al. 1998, 187. Considering the abundant river systems in Gaul, however, it would be surprising if water was not utilized at least in part along this route.

of tin and the dependence upon it for bronze for tools and weapons made tin a metal worth transporting by this method.[384]

Donkeys and mules can only carry a certain load without overstraining the animal. Such animals also require a regular water supply and provisions while on the journey, thus forcing longer routes to avoid desert areas.[385] Yeo declares that a Roman pack mule could carry 250 pounds (ca. 114 kg) while Kuhrt states that a standard ass-load of tin in Old Assyria was ca. 65 kg (130 *minas*).[386] Based on the Roman standard of 100 *libra* (ca. 33 kg) per ingot, a single mule could carry 2-3 ingots. While this might have been practical for short hauls, it would have been prohibitively expensive for long distance trade in lead, as the overall volume of lead transported would be too little to have warranted the expense.

Pack mules were the most efficient mode of transport in the absence of reliable roads. With improved roads, ox-drawn wagons were an option for movement between major population centers. One must assume that this was a common method of bringing lead from a seaport to interior sites, though it is also apparent that many of the centers of secondary lead production were located along the coast (Tyre, Rhodes, Puteoli), thus relegating land transport to the finished product, minimizing waste.

Reliable roads, however, in the ancient world were a relatively rare phenomenon. The Bronze Age was characterized by lengthy caravan routes for luxury goods from the east. By the Archaic period, transportation improvements in the lead-poor Near East, such as the Royal Road of Persia, established in the sixth century B.C.E. between Sardis and Susa, made travel between major areas of the empire widely accessible.[387] While this did little to aid transport from distant mining areas, it may have aided in spreading

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[384] In the first century C.E., tin was approximately 11 times the price of lead (infra, n. 403).

[385] The spread of the use of camels as pack animals in the Iron Age opened up many desert routes in the Near East and Egypt in the first millennium B.C.E.

[386] Yeo 1946, 225; Kuhrt 1998, 26. Moorey (1994, 12) notes that in addition to the two packs of tin, the Assyrian asses also carried 10-12 minas of loose tin along with a few textiles and personal property in a top pack, resulting in an estimated load of 90 kg. Mules, being an ass-horse hybrid, had somewhat more capacity and speed than the donkey or ass, with a fully-laden ass covering approximately 15 miles (ca. 24 km) per day, and mule 25 miles (ca. 40 km) per day (Moorey 1994, 12).

[387] Hdt. 5.52-3; the incredible efficiency of the messenger system established along this road system was noted by Xenophon (*Cyr.* 8.6.17-8) and Herodotus (8.98), but they do not comment on the speed of ordinary travelers.

the use of lead coming into the interior via the coast. Greece was notoriously lacking in efficient road systems. The mountainous interior zones led to the geographical separation of city-states whose foci were primarily coastal. The Romans excelled at road-building, and that may have facilitated the proliferation of lead during that period. Even in this later period, however, land transport was significantly more expensive, and water transport was preferred where possible.[388]

Water Transport

Both seaborne and riverine transport were vital links in the chain of metal distribution. Mines in mountainous areas were often relatively close to rivers that led to more populated and accessible areas. Herodotus provides an account of skin boats that carried heavy cargoes of wine from Armenia down the Euphrates river to Babylon in the early Classical period.[389] It is not unreasonable to surmise that this route was also utilized as far back as the Bronze Age, and for other cargoes such as metals. The lead-silver ores of the Sierra Morena in southern Spain had an outlet to Hispalis (Seville), the primary Roman port on the Guadalquivir River. The abovementioned overland route through Gaul described by Diodorus[390] most likely took advantage of segments of the region's many rivers, such as the Loire or the Garonne. The British lead ingots from the Runcorn wreck (**58**) were found in the River Mersey near the outlet to the Irish Sea, suggesting possible sea transport of metal cargoes around England.

At the other end of the chain is the transport of finished goods into the interior. The Roman port of Ostia was linked to Rome via the Tiber river, with barges drawn by oxen bringing heavy cargoes into the city.[391] The Nile was a major route of penetration into the interior of Egypt throughout its history. Mesopotamians depended on the Tigris

[388] Yeo 1946; Laurence (1998) refines and, in some cases, corrects Yeo's calculations, but still concludes that land transport was more expensive than sea transport for bulk cargoes.
[389] Hdt. 1.194.
[390] Supra n. 383.
[391] Casson, 1959, 225.

and Euphrates, and subsidiary canal systems, to distribute finished goods throughout the region.[392]

In between both of these segments is sea transport. The transportation of significant quantities of metal during the Late Bronze is attested by the shipwrecks at Cape Gelidonya and Uluburun. The latter carried 10 tons of copper and one ton of tin in ingot form.[393] The significant quantities of copper exported from Cyprus in this period must have been distributed initially by sea. Lead ingots from this period are relatively rare, but several found along the coast of Israel are believed to date back as far as the 14th century B.C.E.[394] The abovementioned references to luxury goods from Tarshish in the Old Testament are nearly always associated with long-distance seaborne trade. The sixth-century B.C.E. wreck at Giglio (**6**), off the coast of Italy, carried a mixed cargo which included copper and lead ingots, and may represent the type of trade attested in these Biblical references. The abundance of shipwrecks carrying metal ingots increases over the Classical and Hellenistic periods, reaching a peak in the first centuries B.C.E. and C.E., and attesting to the frequency of seaborne metal transport. Lead ingots predominate in the Roman period, but copper ingots are more common from earlier periods.[395]

ECONOMY OF LEAD

Prices

It is difficult to make broad statements regarding ancient prices for goods, and lead is no exception. Based on various textual references, the best that can be said is that lead is consistently the cheapest of the metals. Prices are sometimes listed outright by

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[392] Due to the limited navigability of the upper Tigris (Moorey 1994, 8), metals from Taurus mountain areas may have come down via overland routes into Nineveh and continued by river from there.
[393] Pulak 2000b, 137.
[394] Kefar Shamir (**1**) and ha-Ḥotrim (**2**).
[395] Despite the Biblical reports that silver and gold came to the east on ships from Tarshish, to date no significant silver or gold cargoes have yet been reported from underwater sites. It is possible that such sites have been discovered and looted without word getting out. It is more likely, however, that such precious metals were consigned to a method of transport with less risk than a conventional merchantman, such as galleys, which were less vulnerable to the vagaries of the winds, or even overland routes, provided that adequate security could be maintained.

weight, at other times they must be calculated based on information about a specific purchase, but raw prices are not particularly informative unless considered in relation to other metal prices or another common commodity.

The earliest reference to the price of lead comes from the Papyrus Rhind, a mathematical text dated to the mid-16th century B.C.E. but believed to be a copy of a document from the second half of the 19th century B.C.E.[396] The price of lead is given as 3 *shaty* per *deben*, with silver given as 6 *shaty*, and gold 12 *shaty*, thus attesting to a gold:silver:lead ratio of 1:2:4.[397] Nriagu suggests that the rarity of lead during this period accounts for its high value.[398] Since the data is actually part of a math problem, however, its reliability is suspect. The overall hierarchy of metal values may reflect reality, but the simple ratio involved suggests the numbers were purposely devised for ease of calculation.[399]

Archaic evidence for prices is lacking, but many references to lead prices appear in Classical inscriptions. In the fourth century B.C.E. lead generally ranged from 1 to 3 drachmas per talent (26 kg), as shown in the building records from Epidauros.[400] Iron from the same set of inscriptions ranges from 13 to 16 drachmas per talent, and tin was approximately 70-140 times more expensive.[401] We again lack evidence of lead prices from the Hellenistic period,[402] but in the Roman period, Pliny documents a lead:tin cost

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[396] Robins and Shute 1987, 11. Such an early date also may cast doubt on the translation of the word lead where tin may have been meant (supra n. 249).
[397] Problem 62 (Robins and Shute 1987, 50).
[398] Nriagu 1983, 127.
[399] While not specifically mentioning lead, Late Bronze Age texts from Ugarit reveal the relative values for gold, silver, copper and *brr* (believed to be tin) as 1:4:800:800 (Stieglitz 1979, 18). Silver to copper values from the Middle Bronze Age Kültepe tablets is 1:130 (Larsen 1967, 178). Such sources appear to be a more realistic representation of the relative values of precious and base metals in the Bronze Age. Nriagu also cites an 18th-dynasty ratio for the three metals as 5:3:1 (per Griffith, 1891-1892), but this again may be for tin and not lead.
[400] Burford 1969, 181. Of the four lead transactions recorded in the building records, the prices per talent calculate to 1 drachma 3 obols, 1 drachma 3¼ obols, 2 drachmas 5¼ obols, and 3 drachmas. This shows an apparent 100% rise in price over seven years, which is presumably a fluctuation and not a unilinear trend. This is consistent with the statement in Aristotle ([*Oec*.] 1353a) that Pythocles urged the state to take lead from Laurion out of private hands, worth two drachmas, and to sell it for six. No unit value is given, but the talent is most likely. Treister (1996, 251) cites a fourth-century inscription from Delphi for the sale of 10 tons of lead for 2½ - 3 drachmas.
[401] For iron see Burford 1969, 181; for tin see Treister 1996, 341.
[402] Treister 1996, 341.

ratio of approximately 1:11.[403] It is clear that despite fluctuations in prices, lead is consistently the cheapest of all the metals. This is generally attributed to the abundance of lead ores around the world. But as the price evidence reflects, the availability of processed lead is not as straightforward a matter as one would expect from the relative abundance of lead ores.

Production Decisions

Despite the widespread distribution of lead-bearing ores, many factors contributed to making certain areas more prone to exploitation than others. Sources with higher silver content were obviously the most attractive, especially in the early periods when lead use was at a relatively low level. Even the Romans, despite their very efficient mining and refining techniques, could not exploit everything they came across. Strabo, for instance, points out that in Castalo there was a type of lead ore which contained silver but not enough to make it profitable.[404] While the initial extraction of lead was often motivated and paid for by the silver produced, the decision to further process litharge into lead was dependent in large part upon issues of labor, fuel, and transportation. It is no accident that the predominant sources of lead in the ancient Mediterranean were located so close to the sea. The early Aegean sources of Siphnos, Thasos, Thrace, and Laurion are all coastally proximate. Later sources of lead important to Roman supplies also had the advantage of easy access to coastal shipping, in particular the mines of Cartagena in Spain, the Iglesiente in Sardinia and the Mendips in Britain.[405]

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[403] Pliny (*HN* 34.161) states that pure tin sold for 80 *denarii* per *libra*, and lead for 7 *denarii*. This lower ratio likely reflects an increase in access to tin in the Roman period, rather than a higher value for lead. Cato (*De Agr.* 21.5) in the second century B.C.E. quotes the cost of lead for the construction of a mill as 4 sesterces; unfortunately, there is no indication of quantity.

[404] Strabo 2.3.10.

[405] The importance of transportation continued into modern times, as demonstrated by the western United States, where it remained economically impractical to exploit the rich lead-silver ores of Utah and Nevada until the completion of the Pacific railway in the 1860s allowed affordable transport of product to market (Ingalls 1908, 208-9).

Labor was always an important factor. Even in recent times labor has been estimated as the single heaviest financial burden in a mining operation.[406] This evaluation was based on a system of daily wages, yet can still be compared to the ancient slave-based mining operations. The use of slaves itself required a significant investment. Aside from providing sustenance for the workers, the poor conditions in large mining operations were often fatal, requiring frequent acquisition of new slaves. Concerning the abovementioned mines at Mt. Sandaracurgium, Strabo relates the common belief that "…often the mine is abandoned because of its unprofitable nature, since there are more than 200 workers but they are continually consumed by sickness and death."[407]

Wages, however, were also a significant factor at times. Xenophon tells of the practice in Classical Athens of private citizens renting their slaves to mine owners for a daily rate of 1 obol per day.[408] He considered this such a profitable venture that he advocated that the state do the same. In addition, even during periods when mining was dominated by slave labor, free citizens sometimes hired themselves out as miners. The contract for the abovementioned Dacian miner provides for a wage of 70 *denarii* plus subsistence for six months.[409] This is roughly the market value of 10 *libra* of lead – not even a single ingot. Depending on the depth of the ore, this might not have been a prohibitive wage for a full labor force.

The cost of labor combined with the difficulties of pursuing veins deep into the earth might have rendered many formerly profitable mines unprofitable. Forbes writes "[e]very 100 foot increase in depth halved the output per shift and more than doubled the price of the product."[410] This is a vital point for the viability of a mine. In discussing the abundance of lead in Britain, Pliny specifically points out that the British ore lies in the

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[406] Ingalls 1908, 212.
[407] Strabo 12.3.40; translation from Humphrey et al. 1998, 190. While this relates to arsenic mines, dangerous fumes were also associated with lead processing, which Vitruvius (8.6.11) notes in relation to the production of lead pipes: "*vapor ex eo insidens corporis artus et inde exurens eripit ex membris eorum sanguinis virtutes*."
[408] Xen. *Ways* 4.14-15.
[409] *CIL* III, p. 948, no. X of the *Dacicae*.
[410] Forbes 1964, 208; the author, however, does not explain how he came to this figure.

topmost layer of the earth. Fresh sources requiring minimal digging, especially in an area with a well-developed transportation infrastructure, is generally a preferable option.

Metallurgical considerations were also relevant. Lead that has not been desilvered is more ductile and less brittle than lead recovered from litharge and, in certain cases, may have commanded a higher price.[411] If the term *plumbum argentarium* does refer to a shinier, brighter lead, as Rottländer suggests,[412] there may have been markets for different types of lead based on the use for which it was intended. We have very little chemical evidence to support such a hypothesis, and what data we do have has so far not been examined in light of that particular question.

Finally, transportation appears to be the primary factor behind the rise of certain lead production centers to the status of extra-regional supplier. Ships provided the most economical means of moving large quantities of the dense material over great distances. The accessibility to the sea of Laurion, Siphnos, Cartagena, and the Mendip Hills can account for their domination of markets over extended periods. Laurion alone was the primary supplier to the Aegean and supplemented Near Eastern sources from at least the sixth through fourth centuries B.C.E., when competition from Phoenician sources arrived in Attica. As Roman use increased demand for both silver and lead, the rate of exhaustion of profitable mines accelerated, thus the succession of three consecutive primary lead production areas in as many centuries – Cartagena-Mazarrón in the first century B.C.E., Sierra Morena in the first century C.E., and Britain in the late first and second centuries C.E.

It is important to keep in mind that smaller, regional mines continued operation in many areas at the same time as these major producers, but their participation in wider trade networks remained limited. Ingots from shipwrecks in the Mediterranean generally represent a single segment of market activity, primarily medium to large cargoes either destined for the open market in a major port, or consigned to a specific buyer for a predetermined use. Focusing on these wrecks sheds light on long-distance merchant

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[411] Craddock 1995, 211.
[412] Rottländer 1986, 16. See also Chapter 2, p. 12.

activity, a powerful economic force, but the effect of local regional circulation for the most part cannot be seen.

CHAPTER IV
LEAD INGOTS

Χρυσηὶς δ᾽ ἡ γυνὴ δέκα μὲν σίτου μυριάδας, τρισχίλια δὲ μολίβδου τάλαντα.[413]

– Polybius 5.89.7

Since the site of metal production was often far from areas of manufacturing or consumption, metals, once refined, were rendered into a convenient form for transport. In common usage, any refined metal rendered into a discrete but otherwise unprocessed form is called an ingot.[414] It is this form of raw metal that is frequently found in shipwrecks and other underwater contexts. A catalog of these sites and the ingots they contained is provided in Appendix A. Shipwreck sites are valuable because they are often independently datable, they can show the variety of ingot types that are coeval, and give us a glimpse of the size and nature of shipments that were circulating around the ancient Mediterranean and beyond. The catalog does not include the many ingots that have been found on land. Such ingots can be problematic as they are often isolated and undatable. In some cases, however, they can provide evidence for the extent of distribution, and in such cases, they have been cited as parallels.

INGOT TYPES

Ingots come in a wide variety of shapes and sizes, some common no matter the type of metal, some unique to a certain metal. They range from the simplest, formed by making a shallow hollow in the ground below the furnace, to those formed in reusable molds with incorporated inscriptions that identify the ingot's producer. The purpose behind many ingot forms is most likely related to transportation. For instance, it has

[413] "And his wife, Chryseis gave one hundred thousand [medimni] of grain and three thousand talents of lead." This describes a portion of aid given to Rhodes after a devastating earthquake in 224 B.C.E.
[414] In English, lead in this form has traditionally been called a *pig*, and its French equivalent, *saumon*, is also frequently used. British scholars still adhere to this usage, but most American publications use the more commonly understood term *ingot*, which will be used in this paper to avoid confusion.

been suggested that the Bronze Age copper oxhide ingots were so shaped for ease of transport – the "feet" of the oxhide shape forming easy handles which may have facilitated strapping to pack animals.[415] The simple plano-convex discoid ingots tend to be small (1-2 kg) and can be packed with relative ease into sacks. The semi-cylindrical and truncated-pyramidal shapes of Roman lead ingots seem to be ideally suited for stacking in a brick-like fashion, as well as for fitting along longitudinal stringers of ships.[416] The need to prevent slippage in the hold would have been a particular worry in the case of lead, the density of which has a greater impact by volume than many other types of cargo, affecting a ship's position in the water and overall handling. The sloped sides of the Roman ingots may also have been optimized to accommodate the bottoms of amphorae as evidenced by the Sud Lavezzi B wreck (**47**). Here amphoras were placed directly between rows of ingots which were arranged longitudinally parallel to the keel.[417]

The overall size of an ingot was likely a factor of weight and density, which was also related to transportation, as well as possibly to furnace capacity. Bronze Age copper oxhide ingots varied in weight, but generally did not exceed 30 kg,[418] thus one would expect that a single mule carried one on each side. Roman Republican lead ingots from Spain were usually of a similar weight (in the range of 100 *libra* or 33 kg), though standards of 120 *libra* (39 kg) and 140 *libra* (46 kg) have been attested for some Imperial ingots.[419] This may have been an ideal weight for human lifting, convenient for the frequent manual shifting required in lading ships. Romano-British ingots were often in the range of 68-88 kg,[420] and it has been suggested that this increase in bulk was a deterrent against theft, being too heavy to easily abscond with. Such a measure would

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[415] For a discussion on the possible reasons behind this shape, see Pulak 2000b, 138-40.

[416] Stacked ingots were found in the Sud Perduto B wreck (**45**) (Bernard and Domergue 1991, Fig. 2). The ingots from the Sud Lavezzi B wreck (**47**) were stowed in longitudinal files between stringers (L'Hour and Long 1985, 39 and Fig. 1), as was the case for those from Saintes-Maries-de-la-Mer (**60**), though the hull did not survive (Long and Domergue 1995, 804 and Fig. 2).

[417] Liou and Domergue 1990, 50 and Figs. 10, 12 and 26.

[418] Pulak 2000b, 140-3. Pulak suggests a standard of 1 talent (28-29 kg) may have been intended for many of the ingots.

[419] Domergue and Liou 1997.

[420] Based on ingots published in *RIB*. The heaviest ingot attested is 101.2 kg (2404.16), dated to the reign of Hadrian, and the lightest 22.7 kg (2404.19), dated to 164-169 C.E.

only have been practical with reliable road access for wagon transport, something at which the Romans excelled. Greeks generally described metal denominations in terms of talents, but we do not know if they ever developed standardized forms.[421] Several ingots found at Laurion were elongated with rounded backs, and one of the two surviving ingots from the Porticello wreck (**9**) was very similar in shape, though the other may have been cast in a *Pinna nobilis* shell.[422]

Some have discussed the possibility that furnace capacity also affected ingot size. If ingots were always created in a single pour from the furnace, then it is possible their size was limited to the capacity of that furnace. Experiments conducted by Whittick showed that striations on the sides of Romano-British ingots, originally thought to represent separate pouring beds, were caused by surface adhesion during the pouring process, proving that most Roman ingots were cast in a single pour.[423] The increased size of British ingots might then have been tied to increased furnace capacity. Whittick, however, also showed that ingots cast in multiple pours demonstrate clear seams with relatively poor adhesion. Examples of such ingots have been found in Britain,[424] as well as on the Saintes-Maries-de-la-Mer 1 (**60**) wreck.[425] These presumably represent cases where the furnace ran out of molten lead before the mold was filled. A new pour was then added to the cooled ingot once a fresh batch of metal was ready. This suggests that the furnace could hold more molten metal than contained in a single ingot, and that furnace capacity was not related to ingot size, at least by the first century C.E. The wide range of weights exhibited in plano-convex ingots, however, might reflect the furnace capacity as a maximum, with each ingot representing a single pour of metal from a given furnace, but with inconsistent initial charge volume and variable levels of lead obtained from the original ore.

Value may also have been a factor in some ingot shapes. Silver ingots, for instance, tended to be smaller than base metal ingots. If a single silver ingot was too

[421] Cf. Polybius 5.89.7 and Burford 1969, 181.
[422] Conophagos 1980, Figs. 13-1 and 13-2; Eiseman and Ridgway 1987, Figs. 4-17 and 4-18.
[423] Whittick 1961. See also Domergue 1998, Figs. 2.2 and 2.4 for clear photos of ingot striations.
[424] Whittick 1961, 107-8.
[425] Long and Domergue 1995, Fig. 7.

large, it may have exceeded the value an individual consumer needed or could afford. In the *hacksilber* hoards of pre-coinage periods, examples of silver bars segmented into smaller units for ease of breakage (described as "chocolate bar ingots") have been found, indicating that common commercial practice was taken into consideration in the design of some silver ingots.[426] In the case of lead, Domergue suggests the 100 *libra* standard of Roman ingots may have been related to tax laws which, in the case of Asia, included a tax of 4 *asses* per 100 *librae* of exported ore.[427] Thus, we see another way in which commercial practice may have influenced ingot production.

TYPOLOGY

The lead ingots presented in the catalog have been assigned types based primarily upon their shape (Table 4.1). Types with known chronological distribution or cultural origin are rare, and are restricted in general to the highly standardized Roman ingots. Instead, I have made typological divisions based upon a combination of technological complexity (sand molds versus reusable molds) and presumed functional intent (accommodation for carrying or lifting). This typology is therefore intended to reflect the level of production complexity, rather than chronometric sequence or culture of origin. Since many publications of lead ingots have established a typology related to the assemblage of one individual wreck, this typology is constructive because it provides a comprehensive framework for comparing ingots from different wrecks. With the exception of the types established by Domergue (discussed below), ingots of the same type were not necessarily produced in the same time period or by the same group of people.

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[426] Schaps 2004, 50.

[427] *Lex portorii Asiae*, as cited in Domergue 1998, 208-9. Note that the law specifies ore rather than lead metal, but it is not unlikely that a similar type of taxation by weight applied to metallic exports.

Table 4.1. A typology of lead ingots based on shape.

A. Plano-convex			
	1. Discoid		
	2. Ovoid		
	3. Fusiform		
	4. Elongated		
	5. Irregular		
	5. *Pinna nobilis*		
B. Basic Mold-Made			
	1. Rectangular-based		
		1.1 Rectangular prism	
		1.2 Truncated pyramid	
		1.3 Rounded back	
	2. Circular-based		
		2.1 Cylindrical disc	
		2.2 Truncated cone	
		2.3 Rounded back	
C. Modified			
	1. Cast modification		
	2. Post-production modification		
D. Specialized Roman Ingots			
	1. Domergue 1 (Parabolic)		
		1.1 Light	
		1.2 Heavy	
	2. Domergue 2 (Straight-sided)		
	4. Domergue 4 (Truncated pyramid)		
		4.1 Light	
		4.2 Heavy	

A: Plano-Convex

Type A is the plano-convex ingot (Fig. 4.1). These are formed by pouring molten metal into a depression in the ground. This depression could be made by hand or the simple expedient of pressing a stone or even the body of a pottery vessel into the prepared surface. Thus, one expects no true mold siblings as the mold is necessarily altered or destroyed by the pouring and retrieval of each ingot. They are convex on the surface in contact with the ground or bottom of the mold, and flat along the top surface exposed to the air while cooling (sometimes called the resting surface). In cross section, they are thickest at or near the center, then slope gradually towards the edges. These are the most organically shaped of all the ingots and often defy easy description. The adjectives applied to them are often derived from food items, another organic and unpredictable medium. This can lead to some cross-cultural confusion, particularly with bread-related terms, as often the same term can be applied to different loaf shapes in different countries and translations are only approximate.

The most common form of type A is the discoid shape (A1), which have a roughly round shape when viewed from above. These are frequently referred to as bun or cake ingots in English, *flan* in French, and *tortas* in Spanish.[428] When the form deviates significantly from round, it is often considered to be ovoid (A2), though whether this shape was deliberately intended or simply the most expedient for the producer at the time is impossible to know. In some cases it is very difficult to differentiate between types A1 and A2, and classification can be arbitrary. An additional elongated shape sometimes encountered is fusiform, sometimes called spindle-shaped, (A3). This is similar to A2, but with the ends pinched into narrow points, which may have functioned as a sort of simple handle. Some plano-convex ingots are in a roughly rectangular shape (A4), though are still relatively organic with rounded corners or ends and no truly straight lines. They are sometimes called elongated, loaf-shaped or oblong. Ingots that cannot be easily classed with any of the preceding shapes are considered irregular (A5). One final form of this type is (A6) the *pinna nobilis*. These are ingots which appear to have been cast in the shell of the *Pinna nobilis*, a bivalve commonly found in the Mediterranean, and which roughly resemble an elongated isosceles triangle with rounded corners. While this is not a sand mold like the others in this category, it has been included here since it was an *ad hoc* mold, not one designed for a specific shape, and was likely also destroyed after first use.

[428] Vallespin Gómez 1986, 311.

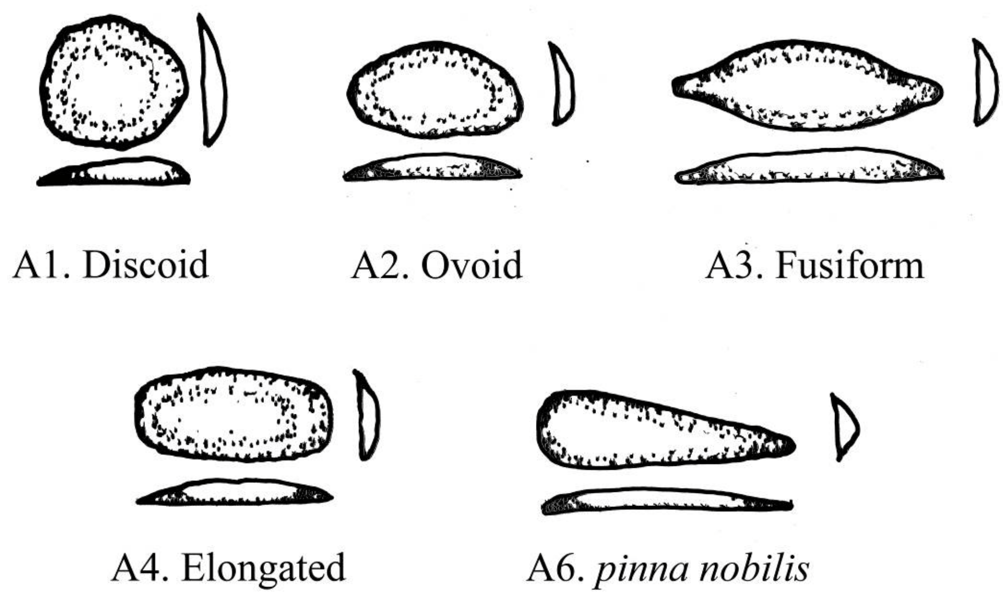

Fig. 4.1. Type A: plano-convex ingots.

It is easy to dismiss plano-convex ingots as primitive and, therefore, representative of an earlier stage of mining technology. Examples, however, have been found dating from the Bronze Age all the way through the Roman period.[429] It is indeed quicker and easier than casting in ceramic or stone molds, which must be manufactured, maintained and replaced, but it does not preclude use by more “advanced” metallurgists in times of haste, economic restriction or stress. The western Greek wreck of Bagaud 2 contained an assortment of stamped tin ingots including types A1, A2, A4, and A5 as well as B2.[430] If one accepts the assumption that ingot shape is tied to workshop, the overall impression of this assemblage is that it represents a collection of output from many different small producers for export to a larger trading center. Thus this type may be typical of a low level of standardization related to widely dispersed production sites and a lack of centralized control over mining operations.

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[429] For example, copper ingots of type A1 have been found on the Uluburun shipwreck (Pulak 1988, 193), and the Phoenician wreck at Bajo de la Campana (**5**), as well as in the Roman wreck at Sancti Petri (**57**), which also carried lead ingots of type D2 (Vallespin Gómez 1986, 310-11).
[430] Long 1987, 151-2 and Fig. 1.

B: Basic Mold-Cast

Type B is the basic mold-made ingot (Fig. 4.2). These are ingots cast in a reusable mold, generally ceramic, but stone or wood may also have been used.[431] Ingots are of a simple geometric shape, which may have had certain functional intent but is not otherwise altered for transport or use. They thus represent a higher standard of production, perhaps the product of a large, long-lived operation or of a producer adhering to standards either by custom or mandate.

Sub-types have been based on the shape of the base, or resting surface, of the ingot. So far only rectangular or circular examples have been found. From this surface, the ingot can rise straight up, forming a rectangular prism (B1.1) or a vertical-sided disc (B2.1). The ends of a B1.1 can be vertical, forming a right rectangular pyramid (more commonly described as a brick), or at parallel, or roughly parallel angles forming a parallelogram. If the sides slope inward as they rise, they generally terminate in a flat plane smaller than that of the base, resulting in a truncated pyramid (B1.2) or truncated cone.[432] If the sides curve up to make an arch, they are described either as semi-spherical (B2.3) or semi-cylindrical (B1.3).

Type B ingots can still be somewhat irregular, with lines not truly linear. It can be difficult to tell how much of this irregularity was original to the ingot, and how much is the result of post-depositional wear, corrosion, and concretion. The ingot from the Porticello wreck (**9.2**) is recognizably similar than other Laurion ingots found on land. Ingots from the Comacchio wreck (**39**), the largest group of Type B ingots in this catalog, are roughly the same size and shape, but with many irregularities that cannot be tied entirely to post-depositional damage. There are not enough examples of this type of ingot to establish a distinct geographical or temporal connection to a particular culture or production center, with the possible exception of the B1.3 ingots from Laurion, which

[431] Domergue et al. (2006, 15) suggests certain ingots from the Comacchio wreck (**39**) may have been cast in wooden molds. Pouring molten metal straight into wood was the established method for making anchor stock cores in the Classical period and had been shown not to significantly damage the wood (Haldane 1980, 25). A stone mold for gold ingots from the Roman period was discovered in Magdalensberg (Domergue 2008, Fig. 32).
[432] So far, no lead ingots have been discovered in the shape of a true cone or true pyramid.

may have been cast to a weight of approximately one Attic talent (ca. 26 kg). There is a possibility that the semi-spherical ingots (B2.3) could be associated with northern European production, since the largest group of them came from the Ploumanac'h wreck (**63**).

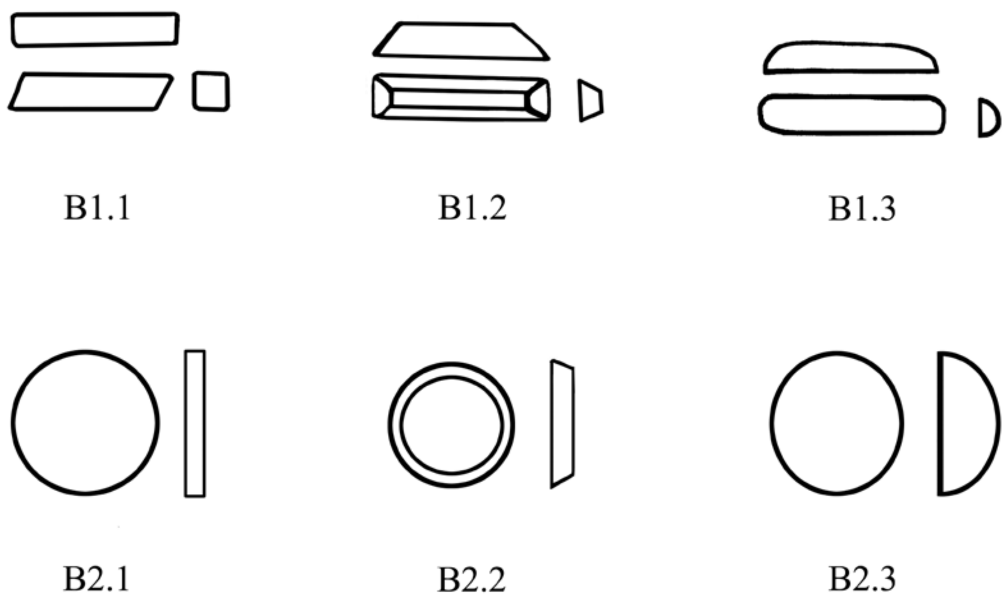

Fig. 4.2. Type B: basic mold-cast ingots.

C: Modified

Type C is the rarest category, with the only examples dating to the Bronze Age. This category is functionally-based, and includes any ingot that has a simple geometric shape, which has been modified for hanging, carrying or transport. The modification may be incorporated into the mold (C1) or created afterward, generally by punching or cutting (C2) (Fig. 4.3). The only examples we have so far involved holes, most likely for suspension to facilitate carrying. The half ingot from the ha-Ḥotrim wreck (**2.1**) has a hole with a slightly raised rim around it in the center of a flat, roughly triangular ingot. The five ingots from the Kefar Shamir wreck (**1.1-5**) are all plano-convex ingots with a hole punched through them near the edge. As so few examples of this type have been found, differentiation has been made based on the stage at which the hole was created, rather than body shape, placement or shape of hole. This distinction helps measure the level of planning involved in the modification, since a cast modification must be intended from the outset, while a secondary modification may be an *ad hoc* accommodation on the part of a producer or merchant. It must be noted, however, that the hole position may be directly related to the method of carrying intended by the producers, and thus may be a culturally derived trait. As further examples come to light, further subdivisions may be possible based on hole shape and/or placement.

Early Egyptian depictions of ingots being carried on poles may explain the C1 example that has been found.[433] There is always a risk that the pierced C2 ingots were originally intended as weights or counterweights, and not trade metals.[434] The researcher must make his or her own judgment based on context, parallels, and physical elements such as inscriptions and use wear evidence.

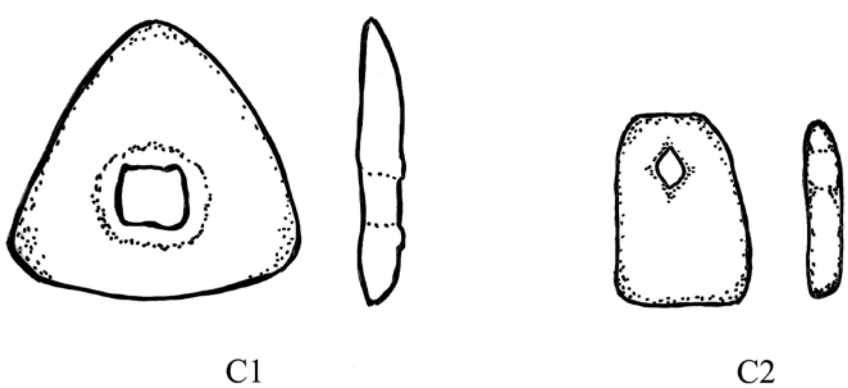

Fig. 4.3. Type C ingots, modified for suspension.

[433] Wachsmann and Raveh 1984, 172 and Fig. 5.
[434] Several cases of this dilemma from land sites are described in Muhly 1988, 263 and Addendum.

D: Specialized Roman Ingots

Over the past four decades, Domergue has developed important standards for publishing Roman lead ingots and their various inscriptions. He has developed a typology of Romano-Iberian ingots, with five types, representing inscribed ingots whose differences in shape and weight can, for the most part, be linked to a time period. However, since his catalog has not yet been published, a detailed description of each type is lacking. The three most commonly encountered types have been reconstructed here from Domergue's various publications, and incorporated as Type D (Fig. 4.4). These ingots frequently bear inscriptions, usually the name of the producer or, later, the reigning emperor, incorporated in the mold. In most cases the inscription appears on the ingot in relief in an indented rectangle, or *cartouche*,[435] set into the back so that the letters are protected from damage during stacking or transport (Fig. 4.5).[436] Up to three cartouches have been attested on a single ingot, usually centered (for single cartouches), or evenly spaced, though not always. To indicate the number of cartouches present, Domergue now appends a letter to the type designation (a = 1, b = 2, c = 3).[437] This convention will be used here.

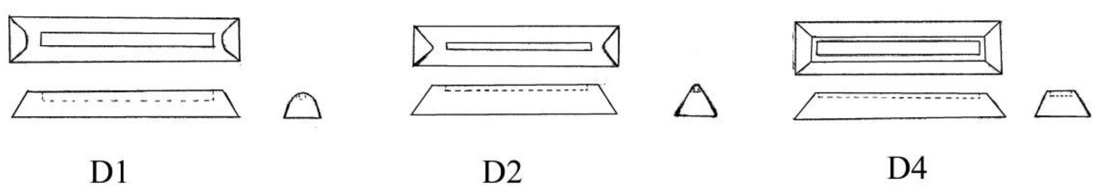

Fig. 4.4. Type D ingots, based on types established by Claude Domergue.

[435] *RIB* refers to this as a *panel*, but the term *cartouche* permeates the French literature on the subject and it will be retained here it to avoid confusion.
[436] Examples of cast inscriptions standing proud of the back surface are rare, and are represented in this catalog only by the ingots from Baie de l'Amitié (**54**) and Punta della Contessa (**67**), which bears molded sea creatures on the back. Some ingots from Britain bear cast inscriptions with no cartouche on the front face or end, but they still bear an inscription in a cartouche on the back.
[437] This designation did not arise until the late 1980s (Colls et al. 1986, 42), and is often only employed in cases of a batch made up of ingots from multiple producers, such as those from Sud Perduto B (**45**) described by Bernard and Domergue (1991, 44).

The first, and earliest, is the Domergue type 1 (D1). This ingot has a trapezoidal longitudinal cross section, with its ends inclined to meet a slightly shorter back. Its transverse cross section is parabolic in shape, showing sides that curve into the back for an overall rounded appearance. Thus, these are often described as semi-cylindrical (or *demi-cylindrique* in French) or as having a rounded back. The width of the base is generally equal to or nearly equal to the height, thus these ingots are not true half cylinders. Originally thought only to date to the Republican period, the discovery of other examples in heavier form from the first century C.E. has led to a subdivision between light (D1.1) and heavy (D1.2) types.

Fig. 4.5. Type D1.1a ingot with molded inscription in cartouche set into the back. (Photo by author.)

D1.1 ingots are associated with the Republican period (late second to mid-first century B.C.E.) when they were commonly produced to a weight standard of 100 *librae* (ca. 33 kg). Names of citizens are the most common inscription on this type of ingot though freedman, business partnerships (*societates*), and symbols are also attested. D1.2 ingots have been found on the Saintes-Maries-de-la-Mer 1 (**60**), with two different weight standards.

Domergue type 2 (D2) ingots have a rectangular base and trapezoidal longitudinal cross section, like D1 ingots. Their sides, however, are straight, leading up to a narrow plane at the back, giving them a roughly triangular transverse section, though the back itself is more rounded than flat.[438] They include a molded inscription in a narrow cartouche on the back. They are generally associated with the first half of the first century C.E. and vary in weight from 43 to 54 kg. Epigraphically, the letters of their mold marks are typically very well-formed and regular. Due to the trapezoidal side view and straight sides, some confusion can arise when reading summary descriptions, as the term “truncated pyramid” might be applied to this type of ingot as well as to D4 ingots.

Domergue type 4 (D4) ingots are shaped overall like a truncated rectangular pyramid, with trapezoidal longitudinal and transverse sections and a wide, flat back.[439] This type is sometimes described as a parallelepiped. In most cases, particularly in Britain, the back is nearly filled by the cartouche with only a small border. In the earlier Spanish versions, however, the cartouche can be of a similar size to that of the earlier D1 and D2 ingots. The letters in these ingots are generally less well formed than those of D2, and in the case of the British ingots, tend to be much larger and thicker. The type is primarily associated with production in Roman Britain, but examples of Spanish, German, and Sardinian origin have been found.[440] The ingots produced in Germany apparently date to the reign of Augustus, making them perhaps the earliest examples of this form.[441] Examples of Spanish origin are restricted to the mid- to late first century C.E. Examples from British sources, often marked with imperial names allowing for easy dating, arise in the mid-first century and continue through the late second century, based on land finds in Britain.[442] The ingots traced to Sardinian ores were produced

[438] See Bernard and Domergue 1991, Fig. 4.
[439] While Domergue (1990, 253) has established a Type 3, tentatively dated to the second half of the first century C.E., there has been no description of this type, and only one unpublished ingot has been so designated (Domergue 1990, Table 10, no. 3001). Space has been left in this typology for the type should it become more widely attested in the future, as well as to remain consistent with Domergue’s numbering system.
[440] Spanish examples were found at Ile Rousse (**50**); the German ingots were found at Saintes-Maries-de-la-Mer 1 (**60**); and the Sardinian examples come from the Porto Pistis wreck (**61**).
[441] Eck 2004, 21.
[442] *RIB* 2404.19-2404.22 all bear the inscription IMP DVOR AVG ANTONINI / ET VERI ARMENIACORVM, dated to 164-9 C.E. based on the title *Armeniacus*, adopted by Verus in 163 C.E.

during the reign of Hadrian (117-138 C.E.). Known examples vary widely in weight, though for the most part they are heavier than D1 and D2 ingots.[443]

Difficulties

The Domergue types are highly specialized, making it difficult to accommodate new discoveries. The ingots from the Comacchio wreck (**39**), for instance, are relatively rudimentary examples of the rectangular-based forms, some with a rounded back, and some closer to troncopyramidal but without cartouches, which do not conform to the well-formed ingots described by Domergue. Since they are rougher forms without molded inscriptions, they have been included instead under Type B, but one should keep in mind that there is a conceptual similarity between them.[444] Type D ingots can be seen to represent a level of standardized production that distinguishes them from contemporaneous Type B ingots.

In regard to the current catalog, there has been some difficulty in applying the appropriate Domergue type to ingots included in early or summary publications, which tend to employ very basic descriptions such as "rounded back," "truncopyramidal" or "trapezoidal in section."[445] In addition, the images included in early publications often only represent a close-up of the inscription itself or a longitudinal profile of the ingot, making identification of the overall shape impossible. Further difficulty has arisen from the fact that Domergue, in one of his earliest works on the subject, provided two

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[443] Ingots from the Saintes-Maries-de-la-Mer 1 wreck (**60**) range from 52-55 kg, conforming to a standard of 140 *librae* (Long and Domergue 1995, 859); British examples range from 34.5 – 101.2 kg (*RIB* 2404.17 and 2404.16), though the majority of British ingots weigh in the range of 75-90 kg; the Sardinian finds ranged from 33.5-39.5 kg (Zucca 1991, 803-808).

[444] Domergue (1987) himself assigned type numbers to these, using the designation V.P. (for Valle Ponti),and thus separating them from other Roman ingots he had studied. Identification is subjective, as evidenced by the fact that Domergue came up with four types (V.P. 1 – 3b), while Berti (1990, 74) found five distinct groups. Both reference only the ingots from the wreck itself. The utility of assigning isolated types for individual cargoes is questionable, so an attempt has been made here to incorporate these ingots into my broader typology that takes into consideration all lead ingots so far found.

[445] Domergue Type 2 ingots are particularly difficult to identify without visual aid, since the back can be considered "rounded" despite the flat sides, yet their longitudinal profile can be described as trapezoidal. For example, the ingots from the Gavetti wreck (**38**) are described by Benoit (1960, 56) as "*demi-cylindres*," but as depicted in *LLGS* (Figs. 30-37) one can see that the apex is rounded but the sides are straight.

schedules of measurements, one for ingots with one cartouche, and another one for ingots with two. These are unfortunately labeled Type 1 and Type 2.[446] Ever since there have been cases where excavators unfamiliar with the history of ingot studies have published ingots as Domergue 1 or 2 based on the number of cartouches rather than the actual ingot shape.[447] These issues have been taken into account in identifying types in the present catalog, and where type cannot be identified with reasonable certainty, it has been identified simply as Type D.

INSCRIPTIONS

Many ancient ingots of various metals were marked with letters and symbols. Marks on commercial goods date back at least as far as the Early Bronze Age, when lumps of clay impressed with a distinctive shape or design were used to seal jars and bags of agricultural goods in Mesopotamia and Egypt.[448] While sealing seals developed into complex, artistic scenes carved into stones, other, less eye-catching methods developed for directly marking objects as they traveled from the point of production to centers of consumption. Unfortunately, most of these early marks, be they on copper ingots from Uluburun[449] or ceramic jars from Enkomi,[450] are usually so brief – consisting of only one or two symbols at most – as to be indecipherable to modern scholars. Some might be numbers or letters, though it is not always possible to identify even this much.

The closest parallel to ingot markings are those on amphorae and other large transport jars, which can be marked both prior to firing and after firing, in a similar fashion to metals. The pre-production marks on amphorae are not precisely equivalent to those on metal ingots, since: a) such marks likely relate to the production of the amphora itself rather than its contents; and b) within a single batch of amphorae, usually only a

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[446] Domergue 1966, Fig. 5.
[447] Domergue (1966, 63) did briefly outline three ingot types, 1, 2 and 3, which eventually became his types I, II and IV, but did not identify the ingots in the article using these type numbers.
[448] The practice may be much older, as Porada (1993, 563 and Fig. 2) notes a seal stamp from Tell Bouqras, Syria, dated to ca. 6500 B.C.E. with a pattern of nested chevrons impressed into it.
[449] Pulak 2000b, 146.
[450] Hirschfeld 2002.

small portion is marked, suggesting that the mark did not need to reach the final consumer, assuming the batch would have been split up between multiple buyers at the point of sale. Nevertheless, post-production marks, usually painted on or scratched into the handles, neck or body of the jar, contained much information similar to that found on lead ingots, particularly in the Roman period, such as weight, region of production, and merchant identity.[451]

Lead, with its soft surface and excellent casting properties, was prone to detailed and relatively lengthy inscriptions, and ingot "stamps" are more common than on other metals.[452] The earliest marks were made by carving or scratching lines by hand with a tool, variously referred to as incised, freehand or, as a noun, a *graffito*. This type of mark persisted into later periods, usually to indicate either weight or a serial number.[453] Some marks were made by punching the segments of the letter or symbol into the surface with the tip of a chisel or similar implement. Others were stamped into the cold metal with a pre-formed symbol or monogram, similar to a die for striking coins. Of these, some impress the letters into the lead, while others impress a square or rectangular field containing the letters or symbol in relief. All of these techniques are considered post-production or secondary, since they were made in the ingot after it was cast. In some cases words or symbols could be incorporated into the mold itself, as described above, making the inscription part of the original cast. These pre-production or primary marks have so far been attested primarily in Roman lead ingots and are very rare in other metals.[454] It has been suggested that the inscription was made in a removable clay slab

[451] A more detailed comparison of Baetican amphorae and ingots from the early Imperial period is included in Chapter 5.
[452] Inscriptions on lead also tend to be better preserved due to the relative stability of the metal, so the frequency of marks on other metal ingots may have been higher than modern evidence suggests.
[453] The set of lead ingots from the Porto Pistis wreck (**61**) is believed to carry serial numbers (Zucca 1991). Numeric inscriptions on copper ingots from Sud Lavezzi B (**47**), however, correspond to neither of these; the numbers 3 and 4 occur most frequently, perhaps suggesting some sort of a batch number system (Liou and Domergue 1991, 115).
[454] Copper ingots from the Cape Gelidonya wreck bear a symbol cast into the matrix (Jones 2007, 96); based on the discovery of a mold, Roman Imperial gold ingots were also endowed with cast inscriptions (Domergue 2008, Fig. 32) .

that could be laid into the mold before pouring, thus accounting for the indented field and raised letters.[455]

Since terminology varies from publication to publication, for the purposes of this catalog, any mark made by scratching lines by hand into the cold metal will be called *freehand*; where distinguishable in published texts or figures, marks made by accumulating segments of a letter with a tool will be referred to as *punched*;[456] marks made by pressing a pre-formed symbol or monogram into the cold or cooling metal, will be considered *stamps*, or *relief stamps* if the letters appear in relief against an indented field; and any words or symbols incorporated into the mold so that they are cast with the ingot itself will be called a *mold mark*. Mold marks are sometimes referred to as *primary stamps*, but the term "stamp" is avoided here to prevent the misconception that these marks derived from impressing the letters into the formed ingot.

The use of mold marks and stamps is an indicator of more centralized organization. The freehand weight marks suggest the expectation of standardized weight units, thus are also associated with more centralized production or at least regulation. The more symbolic freehand marks, such as single letters, are more difficult to interpret, as they might have been made at any point between casting and consumption, and served many different functions depending on individual circumstances.

Much light has been shed on Roman merchant practices through studies of the inscriptions found in Roman ingot cargoes. Mold marks can include tribal or family names, some with direct connections back to central Italy, business ventures, common under the Republic, and, starting in the first century C.E., imperial names. Secondary stamps are believed to represent the names of merchants purchasing ingots either directly from the producer or from another merchant.[457] Freehand numerals are most commonly associated with weight indicators.

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[455] Tylecote (1986, 68) proposes, however, that at least the British examples were made from clay molds that were shaped over wooden molds in which the inscription had been carved.
[456] It can be very difficult to discern this technique strictly from published materials, and sometime even from direct observation, so some examples may be classified in error as freehand.
[457] Early scholars have often interpreted these stamps as some sort of official control marks. See Colls et al. 1986, 66ff. for a detailed discussion of why this is unlikely.

That similar procedures might have been developed in earlier periods is likely but difficult to prove based on the limited inscriptions the ingots contain. It is important, however, to keep in mind the complexity of ancient distribution channels and the variety of explanations possible for even the simplest of symbols preserved on pre-Roman ingots.

INTERPRETING INGOT DATA

When studying ingots, researchers focus on three major types of data. The first is inscription evidence, which is often used to infer a date, cultural affiliation and possible production source for ingots. The earliest modern discoveries of ancient lead ingots come from 16th and 17th-century scholars whose only interest in them was the words they bore.[458] Inscriptions can take the form of letters, numbers, images or simple lines, which can be the most difficult of all to interpret. When one is fortunate enough to find full names attested, such as on Roman republican ingots, parallels are then sought to establish, if possible, the person's place of origin, status, and family affiliation. Such parallels can be found in dedications of public works, coins, graves, guild lists, historical literature and the like. Some markings can provide clues about merchant practices, government control and even ancient marketing efforts, such as the ingots from Sud Perduto B (**45**) with mold marks that greet the buyer (*EMPTOR SALVE*). Not all ingots, however, even from the Roman period, contain this level of detail.

Looking at the whole ingot as an artifact inevitably leads to discussions of standardization, usually demonstrated through a consistent weight, but also suggested when a consistency of size and shape is found. Standardization is a common issue in relation to archaeological data, often used as index for labor investment and organization of production.[459] The concept is closely tied to specialization; however, the technological requirements of the production of metal from ore nearly guarantee specialization in the sense that the producers were not engaged in casual production for

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[458] E.g. *RIB* 2404.01, discovered prior to 1544, and 2404.19, discovered prior to 1712; in both cases the inscription was recorded but no sketch was preserved, and both ingots are now lost.
[459] Rice 1981, Costin 1991, Costin and Hagstrum 1995.

their own use, but were generating a surplus.[460] Suggested reasons for standardization include cost-effectiveness, improved efficiency, and simply the natural result of repetitive action.[461] In the case of raw metals, standardization is most likely motivated by the facilitation of commerce, with prices and taxes often based on weight. Uniformity may also have been aided through the sharing of technological knowledge, particularly in times when state officials were overseeing metal production and bringing practices from the well-established areas to the frontier. Further inferences from standardized ingots, thus, include a well-developed trade system for that metal, strong government control via import/export duties, and large, full-time production sites.

When studying standardization of ingots, one must be aware of several factors that can influence the weight of an ingot. The most obvious, from an archaeological standpoint, is erosion and corrosion under water and even on land. Weight can be lost from edges being ground away, while the conversion of lead to lead carbonate or other compounds reduces the density of the object, resulting in a smaller weight per volume compared to a pure ingot of the same dimensions. Ingots found together can undergo different rates of deterioration, thus care must be taken not to assume a recorded weight difference was inherent to the original set of ingots. Some ingots, particularly Roman examples, bear weight marks that allow us to gauge the original weight as determined in antiquity.[462]

One issue related to production also influences our perception of standardization. When ingots are cast in reusable molds, there is a presumption that the molds were made to a particular standard, but the ingots produced even from a single mold can vary notably in weight. If the mold is not completely filled, the ingot will be less than the intended weight. This difference will also be reflected in the dimensions of the ingots, primarily in height, but also in the base for ingots with angled sides. For example, two ingots and possible mold siblings from the Cartagena B wreck (**30.3** and **30.4**), have the

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[460] See Blackman et al. 1993, 60-1 for a discussion of specialization and the standardization hypothesis in relation to Bronze Age ceramics.
[461] Blackman et al. 1993, 61.
[462] See, for example, the heavily worn ingot from Caesarea (**59.4**) whose surviving stamp (CC) indicates a minimum weight of 200 *librae*, though its present weight is 54.7 kg (ca. 167 *librae*).

same base length, but vary by 1 mm in back length, 3 mm in width, and 10 mm in height, resulting in a weight difference of 1.25 kg (3.82 *librae*). Thus, it is possible for an ingot of the similar dimensions and metal purity to have noticeable differences in weight. In these cases, therefore, a standard weight may have been intended rather than realized in the finished product. The routine practice of weighing and marking ancient ingots shows that such variance was expected and easily accommodated.

A third area of focus in ingot studies is metallurgical analysis. Chemical composition can reveal the purity of the metal and the trace elements present. In the first half of the 20th century the purpose behind such analysis was to attempt to source the metal back to its original ore by the presence of distinctive trace element. This proved impossible due to the various changes wrought by the smelting process, though it can sometimes be used to eliminate certain sources or confirm the type of ore from which the lead was derived. A more reliable form of sourcing is lead isotope analysis, which uses ratios of lead isotopes to match lead samples to their most likely ore source.[463] This can be costly and has not been performed on many of the earlier ingot finds, though attempts are now being made collect these data.[464] Another important piece of information that can be derived from chemical analyses is whether the lead was desilvered or not. This can have implications about the use to which the lead was to be put, and possibly the technological skill of the producers. Analysis of litharge and other refining waste can also shed light on metallurgical processes.[465]

[463] See Chapter 2, 58.
[464] See Trincherini et al. 2009.
[465] Studies of waste products at Laurion (Conophagos 1980, 138-42) and Iberian mines (Domergue 1990, 51-4, and tabs. III-IV) have demonstrated the efficiency of ancient smelting techniques. Analysis of litharge cakes from Habuba Kabira in Syria showed that they resulted from the cupellation of silver rather than purification of gold (Pernicka et al.1998, 128).

CHAPTER V
INGOT CARGOES

te semper anteit saeva Necessitas,
clavos trabales et cuneos manu
gestans aena, nec severus
uncus abest liquidumque plumbum.[466]

– Horace (*Carm*. 1.35.17-20)

Most lead research focuses on the origins of the metal, the organization of primary production and initial distribution. By looking more closely at the wreck sites in combination with lead use patterns, one can begin to paint a broader picture, not only of where the lead was coming from, but where it was going and why. The location, size and composition of these cargoes provide valuable clues that help us reconstruct trends in lead trade over time.

It is clear from the data that the overwhelming majority of lead ingots date from the first century B.C.E. and first century C.E. Of the 68 sites included in this catalog, 24 are associated with the late Republic, 27 with the early Empire, and nearly all of the sites are from the western Mediterranean. Based on historical, archaeological and environmental data, this spike in lead consumption is very real; however, several factors must be considered when discussing the lack of earlier ingot finds. Of primary importance is the intensity of underwater excavation in various regions. France, in particular, has had a vital and well-organized marine archaeology program from the earliest years of the field. Spain and Italy have had no restrictions on sport diving, increasing the likelihood of wreck discovery. Greece, on the other hand, prohibited sport diving along its coasts until 2006, so it is perhaps not surprising that, despite the dominance of Laurion in pre-Roman lead trade, no lead-ingot wrecks have been found in

[466] "And always preceding you is fierce Necessity, wielding spikes and wedges in her bronze hand, lacking neither the rigid clamp nor the molten lead."

Greek waters.[467] Similarly, shipwreck archaeology in the Persian Gulf is nearly non-existent, making it impossible to judge what sorts of ancient cargoes were passing through that area. Permits in countries such as Syria, Egypt, and Libya are difficult to obtain, and underwater efforts are likely to be concentrated on more exotic finds than lead cargoes.

The depositional environment of various areas can also make discovery and recovery of wrecks difficult. The coast of Israel, for instance, where underwater excavation is relatively well-funded, is dominated by shifting sands that can reveal a wreck site one day and hide it the next. This limits the successful investigation of many underwater sites there. The dynamic and treacherous conditions of the northern Atlantic coast, on the other hand, make the massive cargo recovered from the Ploumanac'h wreck (**63**) a rare find, but this does not mean that the shipment itself was a rare event.

Transport methods may also be a factor, particularly in the Bronze Age, when it is believed much lead moved overland rather than by sea. Fluvial wrecks are also relatively rare, due to the heavy sedimentation rates and high currents, which can quickly bury or disperse sunken ships and their cargoes.

CARGO TYPES

In looking at the various contexts in which lead has been found, I have established five categories that characterize the most common situations in which lead was present aboard ship. A sixth category for ingots with no contexts rounds out the list. This is technically not a cargo type, but must be included for the many ingots that have been found on the seabed with no other associated artifacts. All sites in the catalog, therefore, have been assigned one of the following cargo types according to the function of the lead component of the preserved cargo:

(i) primary metal

[467] It should be noted, however, that the Aegean coast of Turkey has been heavily surveyed by the Institute of Nautical Archaeology (INA) which has a long history of cooperation with sponge divers reporting wrecks to archaeologists, and only one possible lead ingot wreck has been reported in the area. The site, off Eski Foça, was reported to INA in 1992 by a sponge diver, but they were unable to investigate the site to confirm the material was actually lead (Pulak and Rogers 1994, 20).

(ii) scrap metal
(iii) raw materials
(iv) staple agricultural products
(v) ship's stores
(vi) isolated finds

It must be stressed, however, that where sites are poorly documented, the assigned type is tentative, and is designated by a question mark in the corresponding tables.

(i) Primary metal cargoes are those for which metal or metal-related products take up a majority of the cargo space on board ship. This category represents newly-extracted material coming directly from a mine or nearby processing point, either in ingot form, as ore, or as a processed mineral, often a metallurgical by-product such as litharge. A single metal may be present, or multiple base metals.[468] A dedicated lead cargo is rare, and so far has only been truly attested in the Mal di Ventre wreck (**21**) carrying over 1000 ingots. Even with this many ingots, based on the size of the ship, it is still possible that a secondary, perishable cargo was also carried.

(ii) The scrap metal cargo is characterized by the presence of many small metal artifacts, usually broken or fragmentary, often interpreted as belonging to an itinerant smith who sails from port to port performing work as needed. This model was established based on the Late Bronze Age shipwreck at Cape Gelidonya where many scrap bronze items, along with ingots of copper and tin, were found in conjunction with an assortment of metalworking tools and casting scrap.[469] These cargoes are typically bronze-related, carrying both scrap along with a small supply of new metal. Lead is relatively rare in this type of cargo, and when found is usually only a minor portion of the full metal complement. The presence of metalworking tools is the key to identifying an actual traveling smith; without them, the cargo may simply belong to a specialist merchant who collects metals and resells them opportunistically. In contrast to the primary metal cargoes, this cargo type suggests an operation in which the ship owner is

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[468] Lead is often found in association with copper [Bajo de la Campana A (**5**), Giglio Campese (**6**), Rochelongue (**7**), Sud Lavezzi B (**47**), Lavezzi A (48), Port Vendres B (**51**), Marseillan Plage (**55**), Sancti Petri (**57**)], but has also been found with tin [Bajo de la Campana A (**5**), Rochelongue (**7**), Port Vendres B (**51**)) and iron (Capo Testa B (**22**)]. In many of these cases, however, the metal was not the primary cargo.
[469] Bass 1961, 274-5.

also the merchant or smith, with a cargo not simply in transit to a market, but functioning as a business inventory, constantly in flux and never fully discharged. Such scrap merchants may have been more common during periods of economic instability.[470] Trade in scrap metals might also have been more intensive in areas without indigenous lead ores such as the Levant and Mesopotamia.[471]

(iii) The raw material cargo is similar to the dedicated metal cargo, but includes additional types of raw materials, such as stone, glass, ivory, wood, or pozzolana. The distinguishing factor is that these all require further processing to reach a finished state, implying that the intended consumer was an artisan, builder, or even a shop owner,[472] rather than a casual consumer at a market or fair. As such, some manufactured building materials, such as bricks and tiles, are also included in this category. Ore and lead minerals appear more frequently in this type of cargo than in the staple cargoes discussed below. The primary example of this type is the Bajo de la Campana A wreck (**5**), which carried a significant quantity of elephant tusks in addition to galena, copper, and tin. Such cargoes suggest an organized acquisition specifically for markets supplying professional consumers who further processed the material into goods for domestic or infrastructural use.

(iv) Staple cargoes are those in which the primary cargo is made up of agricultural staples, such as wine, oil or fish products, often accompanied by a small consignment of domestic ceramics and glass, such as table wares and lamps, as well as a metal component.[473] Such cargoes are identified by the presence of a significant quantity of amphorae in the wreck assemblage. This characterization is biased towards items that readily survive under water, and it is likely that other perishable elements were frequently present in such shipments, such as non-liquid foodstuffs, textiles, leather, or timber. Aside from the metals, this type of cargo requires no further processing before

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[470] Booty from wars has long been confiscated and remelted by conquering powers, however, so recycling likely flourished in times of abundant new metal production.
[471] Raban 1999, 188.
[472] Pigment shops found in Rome and Pompeii attest to specialization in the sale of pigment-related minerals to the general public (Becker and Wilke 2011).
[473] On the rarity of domestic ware cargoes, see Parker (1992b, 96).

reaching the final consumer, suggesting the shipment was destined for a market that supplied the domestic or small-scale professional consumer. The presence of lead and other base metals in this type of cargo becomes more common as agricultural production increases in remote areas, often near mining regions, and the two are shipped back to large population centers for consumption. This is the most common type of cargo associated with lead in the Roman Imperial period, when many farms and villas on the Iberian Peninsula were producing surplus for shipment back to central Italy. The lead component is generally small, often less than 2 tons, and likely to be have been destined for resale on the open market, though it might also represent a consignment of supplies for a specific client or a military establishment.

(v) The fifth context in which lead ingots might be present on a ship is as part of the ship's stores. The frequent use of lead for repairing leaks, as well as for fishing weights, rigging elements and anchor stocks necessitated a supply of raw lead on board for emergencies. A classic example of this is the Madrague de Giens wreck (**23**) which carried a cargo of over 7,500 amphorae and only three lead ingots. The distinction between shipboard supplies and cargo is not always so obvious, particularly in cases where the site has been disturbed prior to excavation, leaving the possibility that ingots had been removed. There is no clear number that qualifies ingots as stores, but in most cases where there are fewer than five it is reasonable to assume that this was their function. The Mahdia wreck (**20**) poses an interesting problem. This ship was carrying a cargo of statuary and architectural pieces from Greece along with at least 12 lead ingots of Spanish origin. Such a quantity of ingots normally be classed as part of a mixed cargo destined for normal market sale, but the additional cargo is not typical of this type of shipment. On the other hand, 12 seems high for ship supplies.[474] The key here might be the presence of bronze statuary and architectural pieces. Since lead was often used for mounting and fixing such items in place, a small supply may have been laid in from a market en route for the erection of these pieces at their final destination.

[474] This was the interpretation preferred by Meier (1994, 780), and given the relatively large size of this vessel, estimated at approximately 40 m in length (Höckmann 1994, 71), it is not impossible that more lead was stocked for repairs than on an average ship.

(vi) Isolated ingot finds are defined as single or small groups of ingots with no accompanying hull or artifacts. These are very common and can be explained in a number of ways. They may represent unintentional loss overboard, jettisoned cargo due to bad sea conditions, or the remains of a wreck site that was heavily disturbed due to post-depositional factors. It is even possible, particularly for harbor sites, that a small group of ingots could have been used as an impromptu anchor for a buoy or some other nautical marker. Isolated finds do not allow us much insight into the economic role of lead in that context, but can contribute to our knowledge of the extent of distribution of a certain type of ingot, particularly when bearing an inscription of known origin.

Ballast and Lading

Another non-cargo function lead ingots might have had on ships is ballast. Ballast is a large quantity of heavy material, often stone, gravel or sand, used to increase a ship's weight in the absence of sufficient cargo in order to keep the ship's center of mass low enough for the vessel to sail safely.[475] The concept of saleable ballast has long been discussed among archaeologists as a possible economizing strategy for making the most of the available space in ship's hold. [476] Instead of carrying worthless material, a captain might have acquired a low-value item to fill the space that could be resold for a low or modest profit at the intended destination, where presumably a high-value cargo would be taken on. Lead would seem to be an ideal candidate for such trade, with its advantageous weight-to-volume ratio or "stowage factor." In ingot form lead would have been easy to rearrange by hand to compensate for changes to the cargo as a ship took on and offloaded cargo at different ports. Unlike other low-value cargoes, the ingots could also be used aboard ship for repairs to replace lost equipment, if necessary. Lead may

[475] See McGrail (1989) for further details on achieving proper stability in sailing vessels.
[476] This discussion has primarily taken place in regard to Greek pottery (Gill 1987; Boardman 1988; Gill 1991). McGrail (1989, 357) pointed out that such a bulky, fragile cargo would not have been useful as ballast, but concedes it may have been used as "space filler." The cargo of broken glass, or cullet, found on the 11th-century Serçe Limanı wreck is a better example of a scrap commodity used as ballast, since the broken glass fragments would have been much denser than intact glass vessels (Bass 2009, 500).

have been used this way on Roman voyages to India where a trade imbalance left the Romans searching for items to fill their holds on the outgoing voyage.[477]

Lead ore could also be used this way. It could easily conform to the space available in the hold in a similar fashion to gravel, with the advantage that it could be sold at its final destination. Dutch traders in the 18th century were known to have done this,[478] and it is possible the ancients took advantage of this option as well. This practice may have been more attractive when lack of resources or political instability in a remote mining region made complete processing difficult, or when there was a market for lead minerals rather than lead metals. The galena found in the sixth-century B.C.E. wreck at Bajo de la Campana A (**5**) may have been intended for cosmetics and medicines, or it may have been destined for a silver refinery, where any silver present in the ore would be captured during the cupellation process, thus obviating the need to desilver it before transport. Litharge, such as that found on the Mazarrón 2 wreck (**4**), may also have been a cheap but moderately profitable ballast option in areas close to silver refining operations.

Related to ballast, smaller quantities of lead may have been used to improve the trim of a vessel. When a ship is fully laden, the cargo must be distributed carefully in order to keep the center of mass in the right point for stability. If a ship is not sitting right in the water, items must be shifted around until the trim is correct. While this has not been attested in historical references, there is a possibility a captain may have taken on a small quantity of lead ingots at a port to balance his ship. This is unlikely to explain the 12 ingots on the Mahdia wreck, since they could hardly have offset imbalances of multiple stone columns, but it may explain the presence of other small batches, such as the 15 found on the El Hornillo wreck (**19**). This would likely only be an easy option in ports where lead ingots were in regular supply, such as Carthago Nova.

Interpreting the lading of lead in shipwrecks, thus, can be challenging. In several wrecks ingots were found at the very bottom of the hold, stowed in lines parallel to the

[477] The *Periplus Maris Erythraei* specifically mentions two Indian ports (Ozênê and Bakarê) where lead and tin could be sold (Casson 1989, 81, 85).
[478] Pulsifer (1888, 356), citing von Justi (1758, 518), who notes this was also a strategy for protecting the secrets of their method for converting galena into red lead.

keel, sometimes between stringers.[479] In these cases, the quantity of ingots has led to the conclusion that they represent a cargo, and the lading was arranged to keep the densest material low and secure from shifting. In the case of the Sud Perduto B wreck (**45**), 48 ingots were found stacked on top of the mast step directly around the base of the mast, showing a different solution to the problem of keeping lead low and secure while maintaining proper trim.[480] Depending on other factors, such as ship design, accompanying cargo, and sailing season, it is possible the ingots were acquired, perhaps from multiple stops along a route, to stabilize the ship, with the intention of selling them later when they were no longer needed.[481] Secondary marks on ingots might help us interpret these situations. The imperial stamps on the Saintes-Maries-de-la-Mer (**60**) ingots, for instance, suggest this was a cargo destined for state use, rather than simple ballast. Due to the difficulty of differentiating saleable ballast from a true cargo, this has not been designated as a cargo type for the purposes of this study.

BRONZE AGE (3200-1200 B.C.E.)

Table 5.1. Bronze Age wrecks containing lead products.

Bronze Age Wrecks (2)				
No.	**Wreck**	**Region**	**Lead component**	**Cargo Category**
1	Kefar Shamir	Haifa	5 ingots	new metal?
2	ha-Ḥotrim	Haifa	several ingot fragments	scrap metal?

From the examination of the use and production of lead in this period, we have seen that lead was most likely circulating within the Aegean in higher quantities than the Near East and Egypt, which were dependent on imported supplies, primarily from

[479] Well-excavated examples include Sud Lavezzi B (**47**) and Saintes-Maries-de-la-Mer 1 (**60**).
[480] Bernard and Domergue 1991, Fig. 2.
[481] McGrail (1989, 357) suggests that ships might have carried partial cargoes of metals or stone over a series of voyages for stability, until a similarly dense cargo was acquired, and proposes this explanation for the large number of bronze objects weighing ca. 60 kg each found at the Bronze Age site at Landgon Bay, Dover, England.

Anatolia and Iran. The only lead ingots so far found have come from three Near Eastern sites, two of which are underwater sites (Table 5.1). Both were found near Haifa off the coast of Israel (Fig. 5.1), and have very little context to help classify the cargoes.

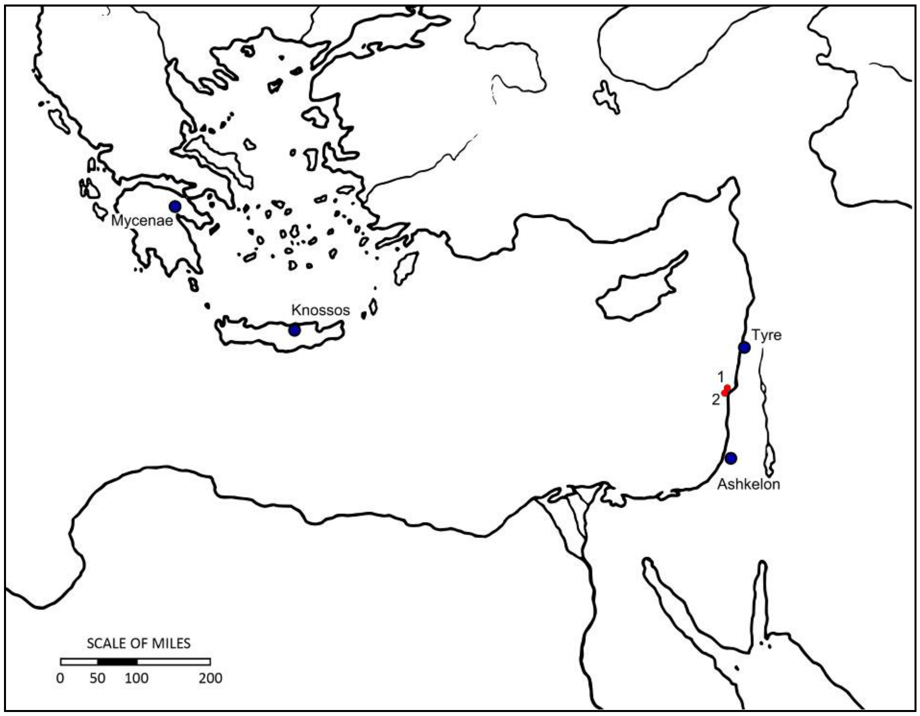

Fig. 5.1. Bronze Age sites listed in Table 5.1

The Kefar Shamir (**1**) ingots were found with tin ingots and in association with Egyptian artifacts, suggesting a mixed metal cargo bound for Egypt. Each of these ingots was inscribed with a single symbol, two roughly in the shape of a cross and two like a 'Y' with an extra stroke vertically bisecting the top. These marks are relatively common in several Aegean scripts and are so basic that they cannot be equated with a single word or concept.[482] These symbols do not have parallels in Egyptian hieroglyphics, however, suggesting that while the ingots may have been destined for Egypt, they were likely

[482] Hirschfeld 2002, Table 1.

marked by non-Egyptian traders. The ha-Ḥotrim pieces were unmarked and found with copper ingots and other broken metal pieces, perhaps representing a scrap metal cargo.

The most important parallel for these lead ingots comes from a land site discovered in the North Palace at Ras Ibn Hani, near Ugarit (modern Ras Shamra). The ingots were of plano-convex discoid shape, but with a more regular shape and refined finish, resembling two ingots from the Kefar Shamir site (**1.4** and **1.5**) but without holes in them.[483] If this similarity in shape links the Kefar Shamir ingots to a Syrian palace workshop, this could support the idea that the ingots were part of a tribute shipment.

There is not enough evidence to say whether lead ingots were standardized in the Bronze Age. The weights from the Kefar Shamir ingots were not published, but their dimensions vary considerably. The Ras Ibn Hani ingots are too fragmentary to reconstruct a meaningful sample size of complete ingot weights.[484] Only a partial ingot survives from the ha-Ḥotrim site and it is very different in shape. The underwater sites are so imprecisely datable, we cannot even say if they are contemporaneous, and thus whether they might reflect either culturally or chronologically distinct ingot traditions.

No information on isotopic analysis has been reported on the Kefar Shamir ingots. The ingot fragment from ha-Ḥotrim has been tested but the results have not yet been published.[485] The Ras Ibn Hani ingots showed two distinct groupings of isotope ratios, neither of which are currently traceable to known ore bodies.[486] Comparison of these ingots with those of the probable tribute shipment from Kefar Shamir would be most illuminating.

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[483] Lagarce 1986, 90 and Fig. 4.
[484] Many were fragments of ingots, although some whole ones were also found, resulting in a wide range of weights, from 9 to 40 kg, for an estimated total of over 600 kg (Lagarce 1986, 90).
[485] Shelley Wachsmann 2010, pers. comm.
[486] Bounni et al. 1998, 49.

ARCHAIC PERIOD (800-510 B.C.E.)

Table 5.2. Archaic wrecks containing lead products.

Archaic Wrecks (6)				
No.	**Wreck**	**Region**	**Lead component**	**Cargo Category**
3	Dómu de S'Órku	Western Sardinia	3+ ingots	isolated
4	Mazarrón 2	Murcia	litharge (2.8 tons); ingot fragments	raw materials
5	Bajo de la Campana A	Murcia	galena; possible ingots	raw materials
6	Giglio Campese A	Tuscany	9 ingots	staples
7	Rochelongue	Hérault	galena	scrap metal
8	Cala Sant Vincenç	Balearic Islands	1 ingot fragment	Stores

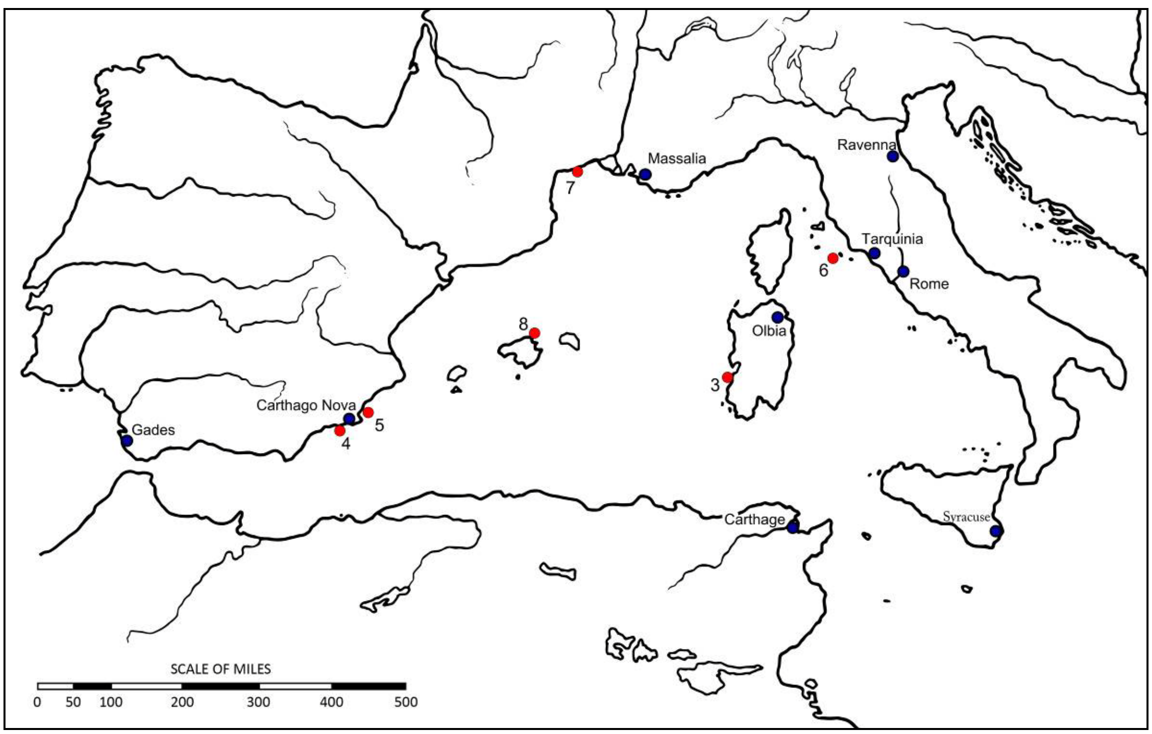

Fig. 5.2. Archaic Period sites listed in Table 5.2.

After the close of the Bronze Age there is a period of approximately 400 years in which we have little evidence for large-scale seaborne trade either in metals or in other commonly-traded goods. By the time lead cargoes began to reappear in the mid-seventh century B.C.E., the western Mediterranean coasts had been colonized along two trajectories. The Phoenicians were expanding along the North African coast and the Iberian peninsula, with a foothold in western Sicily and strong connections in Sardinia, while the Greeks were colonizing southern Italy and eastern Sicily. The primary metal-producing areas were, thus, most closely associated with Phoenicians, although there were diverse mineral resources in central Italy, controlled by the Etruscans.[487] Despite long-term ties between Phoenicians and Etruscans, there is evidence that the Greeks maintained trade ties with the Etruscans, at least until the sixth century B.C.E. when tensions rose to the level of open warfare.[488]

Six lead-bearing wrecks have so far been found dating between 700 and 500 B.C.E.,[489] revealing a great variety of forms in which lead circulated (Table 5.2 and Fig. 5.2). Two wrecks contained raw galena (**5**, **7**), two carried additional scrap metals (**7**, **8**), one a cargo of litharge (**4**), another a range of rare lead alloys (**3**), and only one a straightforward staple cargo with lead ingots (**6**).

The two known Phoenician wrecks, Bajo de la Campana (**5**) and Mazarrón (**4**), carried lead mineral products, galena and litharge respectively, rather than refined lead

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[487] Davies (1935, 65) notes that tin, copper, iron and argentiferous lead ores were all available in the Etruscan-controlled lands of Tuscany; however, how much lead they produced has not been adequately studied. Craddock (1977, 107) reports leaded bronze statuettes from the Late Etruscan period (second and first centuries B.C.E.).

[488] The Battle of Alalia, fought ca. 540 B.C.E., saw a combined Etruscan and Phoenician fleet defeat a Greek force off the coast of Corsica. For at least two centuries before these tensions manifested themselves, there is evidence of trade interaction, apparently peaceful, between the three cultures in the western Mediterranean (Boardman 2001, 38ff). Aubet (2001, 341-6) points to the fall of Tyre to Nebuchadnezzar and the subsequent collapse of Phoenician silver industry in southwestern Spain at beginning of the sixth century B.C.E. as leaving a power vacuum in the western Mediterranean; this may have allowed Greeks a broader range of trade, which was then curtailed as the power of Carthage rose to fill the vacuum in the mid-sixth century B.C.E.

[489] Some would add the Bon Porté A wreck to this list, since an elongated lead bar of rectangular cross section was found at the site (Joncheray 1976, 21 Fig. 2); this is most likely, however, an anchor stock core rather than trade metal.

ingots.[490] This is unusual and suggests that it was the lead or lead product, and not simply the silver the ore contained, that was desired. The ore may have been intended for cupellation, or for use as cosmetics or pigments. The presence of litharge here is an early indication that this was not simply a “waste product” of the silver industry, but a commodity in its own right.

The one example of a probable ingot cargo component comes from the wreck at Giglio Campese (**6**), most likely of Greek origin. This staple cargo consisted of Corinthian finewares, Etruscan amphorae, several lead and copper ingots.[491] This appears to represent a ship bringing goods from the Aegean to colonial markets as well as picking up new cargo in those same western ports. Due to the plentiful amount of lead in the Aegean, Greek colonies were unlikely to have been shipping lead back to the homeland. On the other hand, demand for lead was rising in the Greek world at this time, especially for use in architecture. It may be that the lead was on its way to a Greek colony for a building project. Isotopic data have not been published on the Giglio lead, but would be most illuminating. A Laurion origin would not be surprising, since production there was well established and Greek colonies were dependent on imported metals.

This period also saw increased use of lead aboard ship. The Giglio wreck (**6**), for instance, also contained four lead rings as well as net and line fishing weights.[492] Ingots therefore, may have been present for repairs or to replace losses during the voyage. This may explain the Cala San Vincenç ingot (**9.1**) particularly because it shows signs of having been cut up – one possible result of use at sea. This wreck also contained tin scraps, suggesting a partial scrap metal component. With cargo components of Greek, Iberian and Italian origin, this ship may have been trading in ports around the western Mediterranean.

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[490] Both wrecks are reported to have contained lead ingots as well, but only in minor quantities and none has been well published.
[491] Only 9 lead ingots and 4 copper ingots were recovered from this heavily looted site, but the original complement of metal was reportedly significantly larger (Bound 1991, 26).
[492] Bound 1991, Figs. 57, 58, 60.

The ingots from Dómu de S'Órku (**3**) in Sardinia are particularly unusual. The find consisted of lead ingots along with those of lead-tin and lead-tin-copper alloys. There were also a number of lead plaques with geometric designs. A date between 700 and 400 B.C.E. was provided based on the handle of a Nuragic jar, though it is possible this was intrusive. Treister interprets these ingots as intentional alloys made to order for a particular client.[493] If the date is accurate, this would indicate the presence of a metallurgy workshop on Sardinia with ties to artisans overseas, most likely Phoenicians.

Overall, the lead circulating in this period took many forms, and was not transported in particularly large quantities. The exceptions are the two Phoenician wrecks, which are both raw material cargoes, and suggests the cargo was intended for a market with large-scale professional or infrastructural consumers. The relative abundance of lead in ore or mineral form in this period further suggests that large-scale lead refining was not taking place close to the mines, perhaps due to a relative lack of demand for lead in its metallic form compared to its mineral uses.

CLASSICAL PERIOD (510-336 B.C.E.)

Table 5.3. Classical wrecks containing lead products.

Classical Wrecks (2)				
No.	**Wreck**	**Region**	**Lead component**	**Cargo Category**
9	Porticello	Strait of Messina	20+ ingots	staples
10	Ma'agan Mikhael	Haifa	1 ingot	stores

[493] Treister 1996, 101.

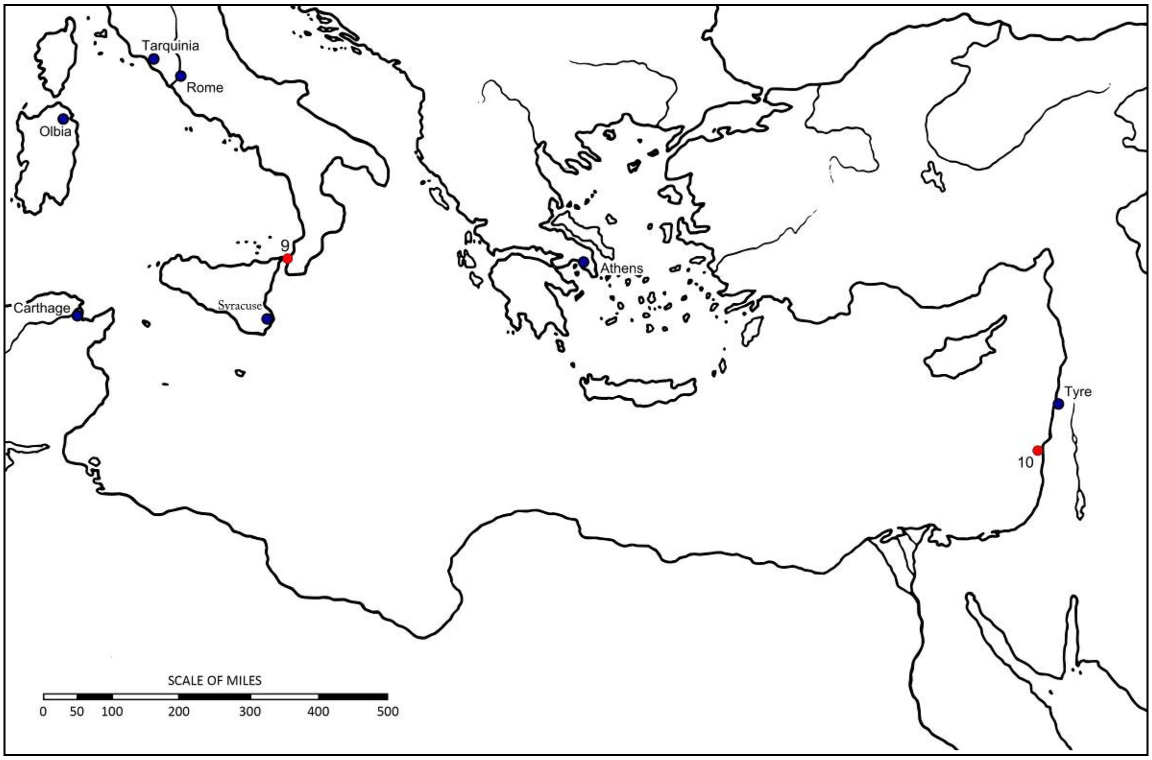

Fig. 5.3. Classical Period sites listed in Table 5.3.

Evidence of lead distribution from wreck sites is meager in this period. We know from archaeological excavations that exploitation continued in Spain, most likely by local Iberians trading with Carthaginian merchants,[494] but so far we have no underwater evidence to trace its movement. Instead, our focus is drawn eastward (Fig. 5.3), where two wrecks have been discovered bearing lead from Laurion (Table 5.3).

While mines in this area had been exploited for silver for centuries, a particularly rich strike was made just prior 484/3 B.C.E, the revenues from which were hoped to be divided equally among all Athenian citizens, but which were instead put toward building a fleet of triremes for the city.[495] The disruptions caused by the subsequent war with Persia led to the cessation of production there for approximately three decades, picking

[494] Domergue 1990, 166-7.
[495] Hdt. 7.144.

up again ca. 450 B.C.E. and continuing into fourth century B.C.E., with some disruptions toward the end of the Peloponnesian War (ca. 413-409 B.C.E.).[496]

One of the ingots from the Porticello wreck (**9.2**) is elongated, rounded-back style (Type B2.3) and weighs approximately 1 Attic talent. At least one lead ingot from the region around Laurion is of the same shape, but it, unfortunately, is not datable.[497] Only one of the Porticello examples bears an inscription, suggesting this was uncommon and that a low level of standardization or regulation prevailed. The fourth-century B.C.E. temple records from Epidaurus, however, report purchases of lead in talents, as with other raw metals.[498] Commercial practices thus might have influenced an informal standardization of one talent for ease of trade. The irregularity in size and weight of the Ma'agan Mikhael ingot (9.85 kg) and the presence of an A6 ingot in the Porticello wreck show that not all ingots conformed to this unofficial standard.

Considering the amount of lead artifacts known from this period, it is surprising to find only two wrecks with lead ingots. This might be a function of low sample size, as Classical wrecks are relatively rare. The locus of consumption in this period, however, was primarily Athens, whose proximity to Laurion did not require long-distance sea transport. Presumably the Near East still needed supplies for cupellation and artisanal work. Due to the shift in power to Persia in the sixth century B.C.E., however, supplies may have been coming in from Anatolian sites such as those exploited in the Bronze Age, with less dependence on Iberian sources.

The Ma'agan Mikhael wreck (**10**), however, does attest to long-distance trade between the Aegean and the Near East. The stone cargo on this ship is believed to have come from Euboea and Cyprus.[499] Galena residue in the bottom of the hold suggests the ship carried an ore cargo prior to the stone. Whether this was discharged in the Aegean

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[496] Treister (1996, 183) notes that despite Thucydides' report (6.97.7) that 20,000 slaves fled the mines to join the Spartans, archaeological evidence suggests operations might have continued there until 406 B.C.E. The earliest lease yet found following this period dates to 367/6 (Crosby 1950, no. 1 (p. 206)). This date still holds per Langdon 1991 (cited by Domergue 2008, 181), with the latest lease dating to 300/299 B.C.E.
[497] Conophagos 1980, Fig. 13-1.
[498] Burford 1969, 181.
[499] Linder and Kahanov 2003, 175-7.

or further east we will never know. The one surviving ingot on the wreck was most likely for shipboard use, so we have yet to find evidence of a lead cargo heading to an eastern port.

The Porticello ship (**9**), discovered in the Straits of Messina, was apparently heading west, possibly to a colony or colonies in western Italy or southern France, when it sank ca. 390 B.C.E.[500] Lead isotope analysis of the ingots linked their source to Laurion. Eiseman expressed surprise in seeing lead headed west, suggesting that sources in Spain, Sardinia, and Italy were either not being mined at the time, or that access to their output was being blocked, possibly for political reasons.[501] Stos-Gale has suggested it was simply a common merchant practice to carry metals in the hold as a sort of prospecting strategy.[502] As with the earlier Giglio lead, it may, however, be a question of cultural ties and demand. The facilities were in place for lead processing in Attica, and thus refined lead for traditional Greek uses might simply have been easier to acquire from the homeland, particularly if shipments of ore or litharge were more common from western sources, as we saw in the Archaic period. The diversity of metals on board the Porticello ship, however, makes interpretation difficult. For example, it is clear from the Epidaurus records, that different quantities of lead were required at different stages of the temple’s construction. In the four entries for lead purchases over seven years, the quantities were 40, 18, 6 and 100 talents.[503] Thus the estimated two dozen ingots from the Porticello wreck could easily have been a shipment destined for a single building project.[504] On the other hand, the presence of scrap bronze and small quantities of a lead/silver alloy may indicate a small scrap metal cargo, perhaps suggesting the ship was owned by a merchant with ties to the bronze producing areas, or that these metals were used for informal currency in more remote areas.

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[500] Eiseman and Ridgeway (1987, 112) suggest this was a tramping vessel serving many ports along the way between Greece and France.
[501] Eiseman 1979, 339.
[502] Stos-Gale 2001, 67.
[503] Burford 1969, 181.
[504] Sicilian builders did not use carved joints, due to the qualities of local stone (Klein 2009, pers. comm.), but other regions settled by the Greeks may have done so.

HELLENISTIC PERIOD (336-146 B.C.E.)

Table 5.4. Hellenistic wrecks containing lead products.

Hellenistic Wrecks (4)				
No.	**Wreck**	**Region**	**Lead component**	**Cargo Category**
11	Cala d'en Ferrer	Balearic Islands	4 ingots	isolated
12	Agde K	Hérault	8 ingots	staples?
13	Agde G	Hérault	litharge	raw materials
14	Cabrera B	Balearic Islands	4 ingots	staples

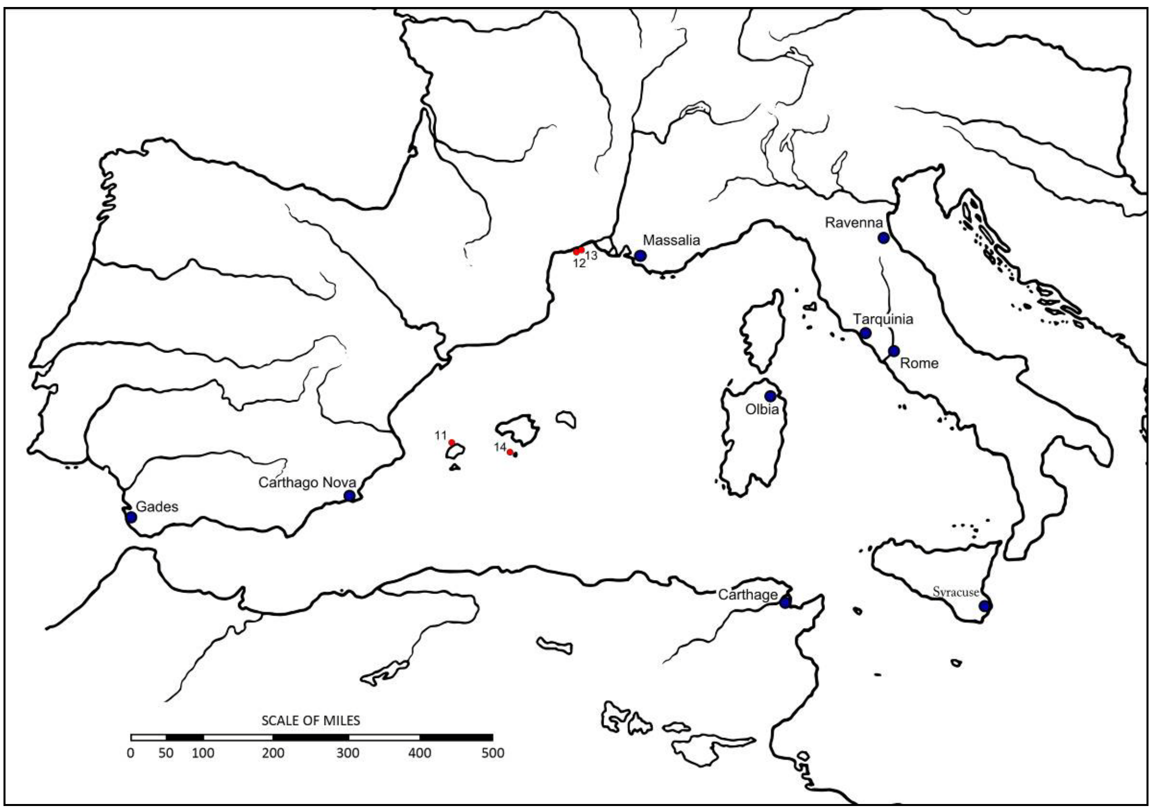

Fig. 5.4. Hellenistic Period sites listed in Table 5.4.

The Hellenistic period is characterized by a number of territorial conflicts, partly as a result of the fragmentation of Alexander’s empire, and partly due to stresses in the west, to some extent related to competition for natural resources. It is probably that disruptions in both lead production and distribution were common in many areas during this period due to the hostilities of the Punic Wars and Rome's conflicts in the Aegean.

Demand for lead likely increased in the third century B.C.E., particularly in the western Mediterranean, at least in the military sphere, as both navies outfitted ships of war.[505] Supplies for Carthage would have flowed from Spain, but where the Romans acquired their lead supplies is less clear. At the time of the building of the initial Roman fleet, Sardinia was allied with Carthage, though the Romans gained control of the island in 238 B.C.E., and may have taken advantage of its resources at that point until it gained access to the ores of Spain. Etruscan sources are possible, and, with its access to the east, Rome might have been supplied from Aegean or Macedonian sources.

Of the four sites in this period (Table 5.4), all are located in the western Mediterranean (Fig. 5.4), and only one, the Cabrera B wreck (**14**), is securely datable.[506] The cargo of litharge (**13**) was given a date by the excavators of fifth through second century B.C.E. due to a perceived Greek cultural affiliation.[507] Such a large cargo (ca. 100 tons) is so far unprecedented in pre-Roman wrecks, however, so one must consider the possibility that this site is of a later date. Unfortunately, no other associated material was reported that might allow further interpretation of the site.

Lead isotope analysis has been performed on samples from the three ingot sites (**11**, **12**, **14**). The ingots from the Cala d'en Ferrer site, believed to be Punic based on their inscriptions, are consistent with ores from the Sierra Morena region, while those from the Adge G and Cabrera B wrecks most closely match ores from the Cartagena region. These mining areas were both under Carthaginian influence during the time in question, though Cartagena was taken by the Romans in 209 B.C.E. Since the Cabrera B wreck precedes this date, its ingots can be linked to pre-Roman production, either by indigenous Iberian metallurgists or Punic colonists. The ingots were cast in *Pinna nobilis*

[505] The Punic wrecks at Marsala, Sicily show evidence of lead sheathing (Frost 1981, 119), proving this technique was not unique to the Greeks and Romans.
[506] Due to my early closing date for the Hellenistic period (146 B.C. as opposed to 31 B.C.E.), my list of Hellenistic sites is significantly shorter than some others (c.f. Hermanns, in press).
[507] Parker 1992a, 45.

shells (Type A6), a technique attested in the early fourth-century B.C.E. Porticello wreck (**9**). The ingots from Agde K (Types A2, A3 and 5), are thus most likely also products of the same metallurgical tradition, but inscriptions are not distinctive enough to identify the language used.[508] An A6 ingot of Greek origin was found on the Porticello wreck from the early fourth century B.C.E., suggesting this casting technique was not unique to the Carthaginians or Iberians, but it does not appear that the Romans adopted the technique.

The date of the Cabrera B wreck (**14**), ca. 250-225 B.C.E., positions it in a time of relative peace, between the First and Second Punic Wars.[509] Its cargo of agricultural products, pottery and lead are typical of the staple cargoes that become common in the Roman period. With products from North Africa, mainland Spain, Ibiza and possibly Italy, the ship appears to reflect a period of peaceful trade around a wide range of the western Mediterranean. The Balearic Islands, where the ship was found, were colonized early by the Phoenicians, and continued their affiliation with the Carthaginians until the end of the Punic Wars. Ibiza, in particular, was an important node in the Carthaginian trade network and was therefore of political value.[510] Thus it is possible the cargo was intended to supply the colonial markets or military forces stationed there.

We have little archaeological evidence for lead trade in the eastern Mediterranean during this period. The 3000 talents of lead sent to support Rhodes after the earthquake in 224 B.C.E. came from Macedonia.[511] Livy notes the silver mines there were shut down by the Romans in 167 B.C.E., implying they were regularly exploited until then. We know that the Laurion mines declined in production and were virtually abandoned by the end of the second century B.C.E. The proposal of Pythocles for Athens to take over the lead produced at Laurion from private citizens[512] could indicate that while silver was tapering off, a profit was still being made from selling the lead,

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[508] The ingots from this site are all marked with a symbol that can be interpreted as Greek, Latin or Iberian.
[509] The First Punic War ended in 241 B.C.E. and the peace lasted until 218 B.C.E.
[510] Wagner 1990, 156.
[511] Polybius 5.89.7.
[512] Arist. [*Oec.*] 1353[a].

particularly as demand for the metal grew more widespread. This is the earliest written record of lead as a possible income-generating resource for the state.

ROMAN REPUBLIC (146 – 31 B.C.E)

Table 5.5. Roman Republican wrecks containing lead products.

Roman Republican Wrecks (24)				
No.	**Wreck**	**Region**	**Lead component**	**Cargo Category**
15	Algajola	Western Corsica	44 ingots	raw materials?
16	Agde J	Hérault	6 ingots	staple
17	Escombreras 2	Murcia	4 ingots	staple
18	Punta dell'Arco	Campania	14 ingots	staple?
19	El Hornillo	Murcia	15 ingots	staple
20	Mahdia	Mahdia	12 ingots	stores
21	Mal di Ventre	Western Sardinia	981+ ingots	primary metal
22	Capo Testa B	Straits of Bonifacio	4 ingots	stores
23	Madrague de Giens	Var	3 ingots	stores
24	Planier C	Bouches-du-Rhône	litharge	staples
25	Capo Passero	Sicily	13 ingots	unknown
26	Punta Falcone	Western Sardinia	16 ingots	isolated
27	Bajo de Dentro	Murcia	42/49 ingots	isolated
28	Cala Cartoe	Eastern Sardinia	1 ingots	isolated
29	Cap Spartel	Tangier-Tétouan	40+ ingots	staples?
30	Cartagena B	Murcia	14-16 ingots	isolated
31	La Chrétienne A	Var	1 ingot	stores
32	Dénia	Valencia	1 ingot	isolated
33	Les Moines	Western Corsica	1 ingot	isolated
34	Les Moines 3	Western Corsica	3 ingots	isolated
35	Pointe de Bonnieu	Martigues	1 ingot	isolated
36	Sanguinaires B	Western Corsica	7 ingots	isolated
37	Scoglio Businco	Western Sardinia	7 ingots	isolated
38	Gavetti	Straits of Bonifacio	9 ingots	isolated

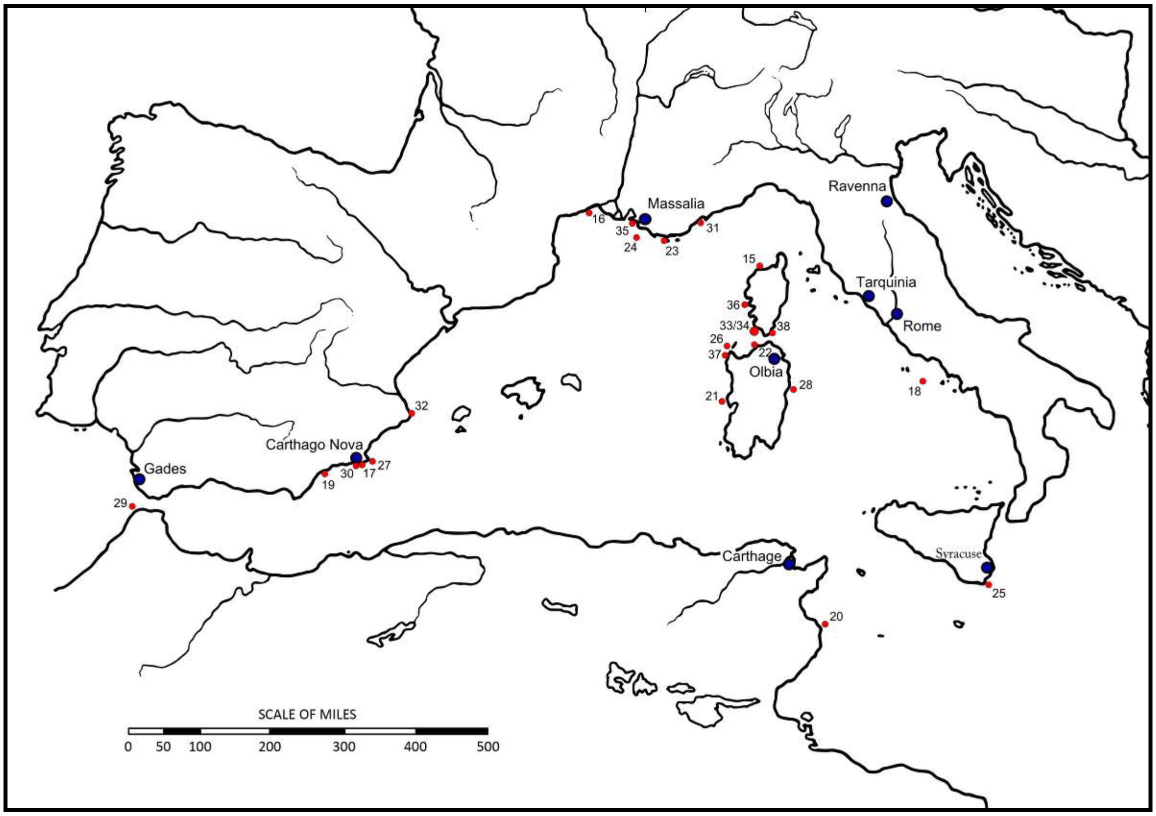

Fig. 5.5. Roman Republican sites listed in Table 5.5.

The 24 sites from this period (Table 5.5) are concentrated chronologically in the first century B.C.E. and geographically in three main regions: the shores around Cartagena harbor (**17**, **27**, **30**), the coast just west and east of Massalia (**16**, **23**, **24**, **31**), and the Straits of Bonifacio, especially its western approach (**22**, **26**, **33**, **34**, **36**, **37**, **38**). These three areas are important nodes in the ancient trade routes of the western Mediterranean (Fig. 5.6). Carthago Nova was not only an outlet for the abundant metals and crops of the area, but a clearing house for products from further west and the interior.[513] Massalia continued to prosper as a trading city as the Romans expanded into the western Mediterranean, acting as a gateway into Gaul. The Straits of Bonifacio provided a relatively direct route to central Italy from Spain, allowing sailors to bypass the lengthy coastal journey around southern France, in favor of following the Balearic

[513] Livy 26.43.

Islands east between Corsica and Sardinia then across the Tyrrhenian Sea to Ostia or Puteoli.[514]

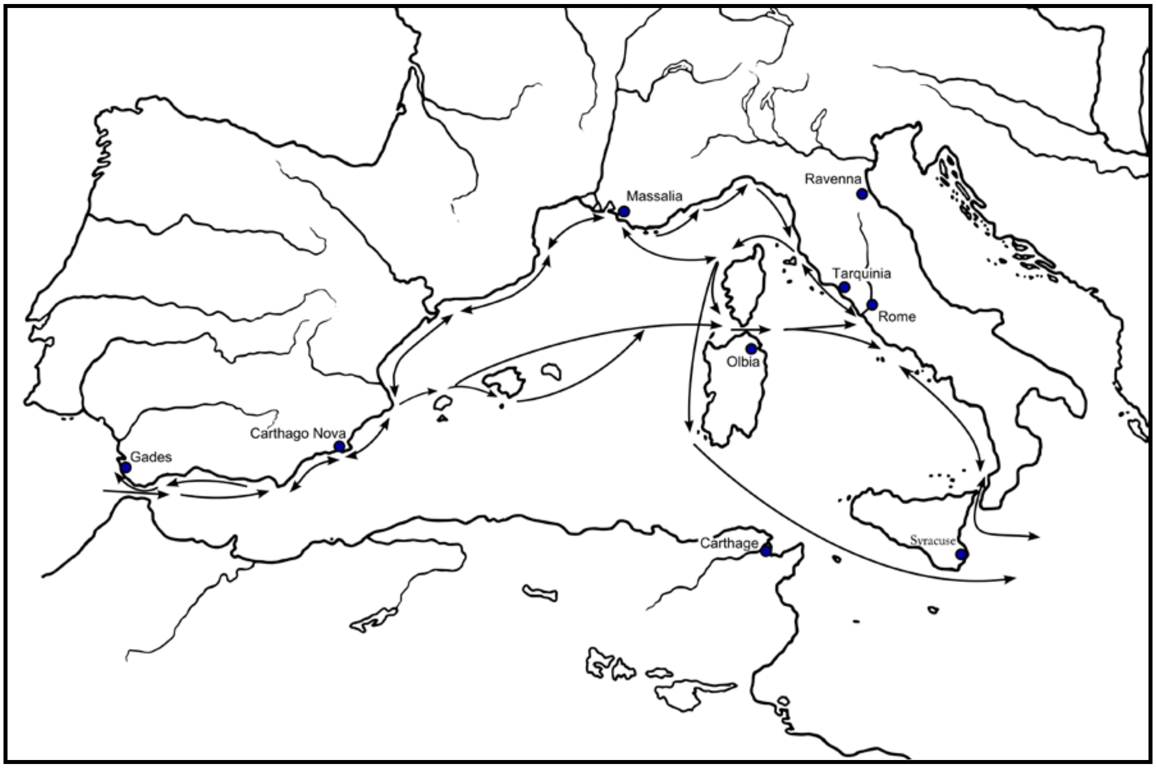

Fig. 5.6. Common trade routes in the western Mediterranean in the Roman period.

Despite the increased number of underwater ingot finds from this period, nearly half are isolated occurrences, with no associated hull or cargo remains (**26-28**, **30**, **32-38**) (Fig. 5.7). The presence of isolated ingots in harbors, such as Cartagena (**30**) and Dénia (**32**) is not surprising, given that ingots could easily have been dropped overboard during

[514] Hodge (1998, 28) points out that, based on modern sailing guidelines, this was likely a unidirectional route, with traffic going from west to east through the perilous straits; ships attempting to sail east to west can find themselves becalmed. The Rome to Massalia route was most likely also unidirectional, following the Italian coast northward, turning west north of Elba to northern Corsica, and from there continuing north and east along the Côte d’Azur. Sailing to the eastern Mediterranean from Massalia traditionally involved sailing south, keeping west of Corsica, Sardinia and Sicily, and then turning east; presumably to reach Rome, ships would have started on this route and turned east at the Straits of Bonifacio.

lading, repair work or even fitting out new ships.[515] The smattering of ingots along the sparsely-settled western coasts of Corsica and Sardinia (**26**, **33**, **34**, **36**, **37**) are more likely to have come from ships traveling south from Massalia or those blown off course while attempting to pass through the Straits of Bonifacio, but whose primary wreck site has not been located. These ingots might have been dragged from the wreck site by fishing nets.

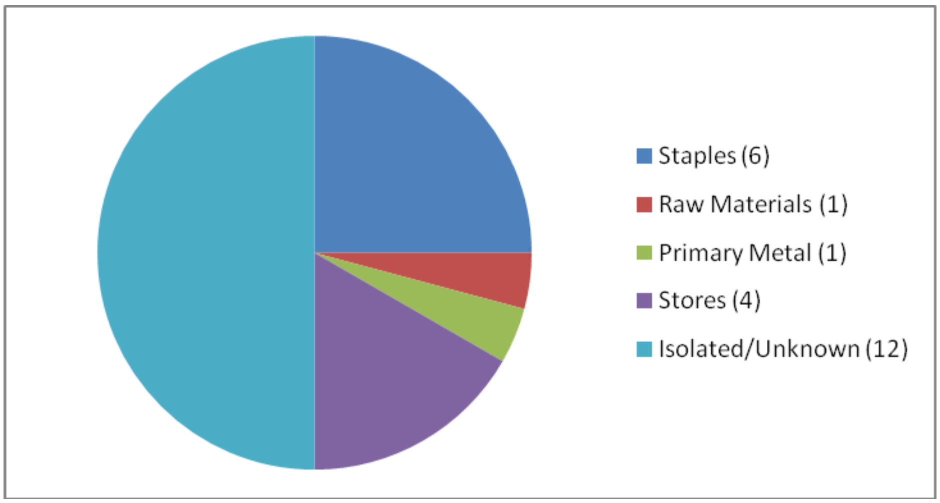

Fig. 5.7. Types of lead cargoes discovered in Republican wrecks.

Four groups of ingots can be identified as probable ship's stores (**20**, **22**, **23**, **31**). Of these, the most interesting is that of the Mahdia wreck (**20**). As mentioned above, this vessel was carrying art and architectural material from Greece and was found off the coast of North Africa. The fact that it was carrying ingots of Spanish origin demonstrates that lead ingots were widely available and not directly associated with a ship's most recent route. While one expects ingots to have been available in Roman and Campanian ports, it is also possible they were regularly available in large ports with significant overseas traffic, such as Massalia, Gades and Syracuse. The small cache of ingots from

[515] We do not have a reliable list of harbors in which Roman shipbuilding regularly took place, but as Cartagena was the site of such activity under Punic control (see below, p. 131), it likely continued to be a shipbuilding center under the Romans.

the Capo Passero wreck (**25**) at the southeastern tip of Sicily might thus represent lead supplies either being delivered to or purchased from the markets of Syracuse.[516]

There are only nine sites where lead ingots can be identified as a cargo component. Of these, six are staple cargoes (**16**, **17**, **18**, **19, 24**, **29**).[517] These cargoes are characterized primarily by Dressel 1(a-c) amphorae, along with a few Lamboglia 2 amphorae. Such amphorae are associated with the wine trade and were predominantly produced in Italy.[518] The export of wine to Gaul, Spain (and Northern Europe) in this period was common. The thousands of Dressel 1 amphorae discovered on the Madrague de Giens (**23**) wreck, for example, were produced in southern Latium.[519]

The combination of Italian amphorae and Iberian raw materials, thus, could represent tramping trade, where small consignments were picked up and discharged at different ports along a coastal route, rather than directed trade between Italy and a single port – traders supplying known markets with familiar Roman goods and needed metals from distant locations. In the case of the western Mediterranean in the first century B.C.E., however, a great deal of Roman activity in the area was related to military campaigns. The presence of Dressel 1 amphorae in Roman settlements linked to military activity in southern Gaul and Spain has been noted,[520] suggesting that some of these shipments might represent garrison provisions.

The wrecks at El Hornillo (**19**) and Cap Spartel (**29**) were found west of Cartagena, indicating that the movement of lead was not simply unidirectional or siphoned through Rome for redistribution. Certain silver mines in western Spain, for instance, needed lead to help extract the precious metal from lead-poor ores, as

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[516] To date only the ingots from the site have been published in detail, though amphorae and other materials were found (Lopes 2006).

[517] The wreck of Cap Spartel (**29)** lacks additional surviving cargo, but based on its remote location and the quantity of lead, this was likely also a mixed staple cargo, the more fragile elements having been lost in the high energy environment of the site. It is also likely the Capo Passero wreck (**25**), currently unclassified, also falls into this category, but we must await further publication of the site before including it in the analysis.

[518] Paterson 1982. Dressel 1 production sites have been identified in Etruria, Latium, and Campania (Hesnard et al. 1989, 21-30). Lamboglia 2 production has been linked to the Adriatic coast (Tchernia 1986, 54).

[519] DRASSM 2010.

[520] Many of the Dressel 1 and Graeco-Italic amphorae samples analyzed by Hesnard et al. (1989) were acquired from military settlements in Gaul and northern Spain.

evidenced by an ingot from Cartagena discovered at the Rio Tinto mine.[521] It is also likely that there were shipyards in Cadiz, which would have needed a supply of lead.

The Algajola wreck (**15**) has been tentatively classed as a raw materials cargo due to the presence of ceramic tile fragments at the site, which may indicate a partial cargo of building materials. There is, however, a possibility that the ceramic tiles were part of the ship, such as for a galley roof or hearth, though this does appear to have been a common feature of ships of the Republican period.[522] This wreck has been given a possible second century or early first century B.C.E. date, based on the presence of Dressel 1a amphora fragments.[523] If the second century date could be further supported, the type D1 ingots found there would be the earliest instance of standardized Roman lead production in Hispania.[524]

Two wrecks, Bajo de Dentro (**27**) and Cap Spartel (**29**), I have tentatively identified as staple cargoes due to the significant but moderate number of ingots reported (over 40 each or approximately 1.3 – 1.6 tons). In each case, underwater investigation revealed no other cargo, strongly suggesting the loss of additional perishable goods. According to Livy, when Scipio captured the Punic stronghold of Carthago Nova, 63 merchant ships were seized, the cargoes of which included grain, weapons, additional bronze (or copper) and iron, linen, esparto and other shipbuilding supplies.[525] This list is

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[521] Domergue 1990, 58, n. 54.

[522] At least two Roman wrecks with possible tiled roof structures have been published–the Albenga wreck (ca. 100-80 B.C.E.) and the Guernsey wreck (third century C.E.) (Beltrame 2002, 95-6). The best evidence for a tiled cabin roof comes from the seventh century C.E. wreck at Yassi Ada (Bass and van Doorninck 1982:87-110). The abundance of tile carried is perhaps the best way to distinguish between cargo and use aboard ship. For instance, the Ploumanac'h wreck (**63**) contained a only small number of tile fragments (L'Hour 1987b, 114), suggesting that these were not cargo, but rather part of the ship, and thus it has been classified as a primary metal cargo. Since few details have been published on the material from Algajola, this factor cannot be weighed with any reliance.

[523] Dressel 1a amphorae are believed to have been produced between 130 B.C.E. and ca. 50 B.C.E. (Peacock and Williams 1986, 87).

[524] These ingots have have been tentatively identified as type D1b, based on a reference to the ingots having two cartouches on the back (Trincherini et al. 2009, Table 2); no images have been published. No inscriptions survive (Liou 1973, 606). Dressel 1a amphora remains have also be found on Escombreras 2 (**17**) and La Chrétienne A (**31**), both of which have been dated to the early first century B.C.E.

[525] Livy 26.47.9-10: "*Naves onerariae sexaginta tres in portu expugnatae captaeque, quaedam cum suis oneribus, frumento, armis, aere praeterea ferroque et linteis et sparto et navali alia materia ad classem aedificiandam*..." Esparto grass and linen were important naval supplies, the former for ropes and twine, the latter for sails.

restricted to goods which supported the war effort, particularly ship construction, but gives a good indication of the types of perishable cargoes that might have complemented the metal and amphora cargoes found in the region.[526]

Only one indisputable primary metal cargo was found: the Mal di Ventre wreck (**21**), off the coast of Sardinia. This ship carried over 30 tons of lead ingots, linked by isotopic analysis and inscriptions to the mines of Carthago Nova. The significant quantity of lead shot also found on board, might indicate the ship was carrying military supplies.[527] As there were many factions contending for power in Rome over the course of the first century B.C.E., this is not an improbable suggestion and, as such, would represent the only clearly identifiable military lead cargo yet found.

Origins

All of the ingots so far subjected to lead isotope analysis have been consistent with ores from the Cartagena-Mazarrón region.[528] Several factors contribute to the dominance of this area for lead production. First, it was conquered early by the Romans, and held firm without native unrest throughout the tumultuous political upheavals of the first century B.C. Its political stability allowed trade and industry to flourish while the contest continued for the rest of the peninsula. Secondly, the proximity of the ore deposits to the busy harbor made the transport of heavy loads easier than for more remote areas such as the interior Sierra Morena range, where silver shipments no doubt took priority over lead.[529]

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[526] The depth of the Bajo de Dentro site (**27**), however, was not reported; if shallow enough it may have been partially salvaged in ancient times, leaving the possibility that it was a new metal cargo. The depth of the Cap Spartel (**29**) site was also not reported, but Ponsich (1966, 1273) reported a high energy, sandy environment; such environments tend to be shallow, so salvage might have been possible, unless the energy levels were high enough to fill in the wreck quickly.
[527] Salvi 1995, 247.
[528] The sample consists of ingots from wrecks **15**, **16**, **17**, **20**, **21**, **23**, **27**, **34**, and **35.**
[529] While there is evidence that Romans were exploiting the silver mines of the Sierra Morena during this period (Domergue 1990, 189-91), significant lead exports from this region, identified isotopically and epigraphically, do not regularly appear until the Imperial period. Domergue (1990, 183-5) also points out that the political situation in the Sierra Morena districts was relative unstable until 138 B.C.E., confining significant mining in the region to the last century of the Republic.

The importance of the harbor of Carthago Nova itself might also have been a factor. It was described by Livy as ideally situated on the route to Africa and large enough to house a substantial fleet.[530] The demand for lead for the outfitting and repair of ships might have stimulated production in nearby mines, rather than relying on imports from sources previously exploited by Rome.[531] This may help explain the high frequency of isolated ingot finds in the harbor, as well as the apparent delay in the commercial export of the metal. Even though Cartagena was conquered in 209 B.C.E., all of the securely datable ingots from Republican shipwrecks come from the first century B.C.E., or possibly the late second century in the case of Algajola (**15**). The early entrepreneurial mining efforts of Roman citizens were clearly tied to silver, and it is possible that lead production did not play a significant role in this initial activity. A subsidiary demand for the export of lead, thus, may have been stimulated by increased fleet activity in the western Mediterranean, as well as the expansion of Roman settlements into undeveloped regions with a concomitant increase in infrastructural need for lead. While literary sources are relatively quiet on the subject of lead, the ingots themselves allow us a window into the scope of their production and distribution not available to us for prior periods.

Ingot Characteristics

The extensive use of mold marks on lead ingots in the late Republic has drawn a great deal of attention to this otherwise humble metal. These inscriptions generally consist of an individual name, two names or a business partnership, occasionally accompanied by a symbol such as a dolphin, anchor or caduceus. The names are presumed to represent mine owners, operators or lessees, since they were cast into the ingot at the foundry. It is common to assume that the person who extracted the ore was

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530 Livy 26.42.4-5: "*sitam praeterea cum opportune ad traiciendum in Africam, tum super portum satis amplum quantaevis classi et nescio an unum in Hispaniae ora qua nostro adiacet mari*."

531 As mentioned in the Hellenistic section above, we know little about where the Romans acquired their lead while the Carthaginians controlled the resources of the Iberian peninsula. Pliny (*HN* 3.24) states that metal extraction had been prohibited in Italy, but does not tell us how early this policy was effected. Sardinia is a likely candidate, having been won by the Romans from the Carthaginians in 238 B.C.E.

also processing the finished lead, though it must be kept in mind, as with the case of Laurion, that the initial extraction was oriented toward silver, and that it is possible that ore of low silver content or litharge from cupellation was sold off to a separate party for reprocessing into lead.[532]

Mold marks allow us to track the distribution of a single producer's output, in terms of geography and relative quantity, to identify separate producers within a single cargo of ingots, and in some cases to link ingot production to families or tribes known through other historical sources. While most agree that the names attested in mold marks represent those responsible for their manufacture, few speculate on the purpose behind mold marks.[533]

The closest equivalent to this type of mark on other media is the incorporation of personal names or initials into the fabric of ceramic products, particularly amphorae, prior to firing, which is attested in the Greek world beginning in the fourth century B.C.E. Such marks appear on only a small percentage of all amphorae, and are generally associated with highly regulated production areas such as Thasos and Knidos. In Italy, they first appear on amphorae produced in Magna Graecia in the fourth and third centuries and still utilize Greek script and conventions. The earliest Latin inscriptions come from the end of the third century B.C.E. and appear to have originated in regions of central Italy such as Campania and Latium.[534] There has been much debate as to whether these marks represent the names of the potter or pottery workshop in which the amphora was produced, or the name of the estate or estate owner where it was filled, but no agreement has been reached.[535] Since the earliest ingots with mold marks also have ties to Campanian families, it is not unlikely that the tradition of marking ingots was adapted from the amphora stamping tradition of central Italy.

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[532] We have no written evidence to suggest this was the case, nor any to point to the contrary.
[533] Herschend (1995) does attempt to address this questions, although his observations are based on three Imperial wrecks, and he does not examine the origin and development of ingot inscriptions over time.
[534] Manacorda 1986, 582-3.
[535] See Peacock and Williams 1986, 9-10 for a summary of the argument. They note that, for some estates at least, the estate might have produced its own pottery, thus the owner would have been the same either way, but this could not have been the case all the time.

It is generally assumed that mold marks are a form of brand, promoting name recognition in a competitive market. Brand names function by linking a particular product with high quality and satisfaction in a consumer's mind. As such, the use of inscriptions for name recognition in wine or oil is a sensible suggestion. Wine, in particular, is a highly variable product with many different flavors, leading to strong consumer preferences. Based on chemical analyses of lead ingots, however, there is very little variability in lead quality, with most Republican ingots being 99% pure lead or greater.[536] Pliny did note different types of lead, identified simply by region of o rigin, but further stated that there was little difference in their quality if processed properly.[537] Geographical information, however, is rarely included on ingot stamps, and when it is, it is thought to designate ingots produced in municipally-owned mines. A difference in quality might have occurred based on whether the metal came from fresh ore or recovered from litharge,[538] though there does not appear to be any attempt to distinguish this in mold marks. If such a distinction existed, it was likely lost on casual consumers, but certain professional consumers, such as artists working in bronze, might have been more aware of these differences and sought out providers accordingly. If such was the case, name recognition might have been important, presuming a producer was consistent in his production method.

Herschend, looking at the early Imperial period, suggests mold marks were intended for the merchants buying batches of ingots, like wholesalers, rather than for individuals buying lead in a marketplace in Rome.[539] It is certainly likely that individual consumers did not know one producer from the other. Merchants might have benefited from recognizing a producer but, again, it was not likely an issue of quality, although

[536] This is based primarily on analyses derived from wet chemical tests, found in many older publications (*LLGS*; Tylecote 1986, Table 38). Chemical composition data is rare in more recent sources, where isotopic analysis for sourcing is stressed; however instrumental analysis performed on one ingot from the Mal di Ventre wreck (**21**) for purposes of determining the metal's suitability for use in low radioactivity experiments also revealed a purity of 99% (Alessandro et al. 1991, 116).
[537] Plin. *HN* 34.164: "*Nigri generibus haec sunt nomina: Ovetanum, Caprariense, Oleastrense, nec differentia ulla scoria modo excocta diligenter*."
[538] A more rigorous comparative study of the chemical composition of lead ingots could help determine if distinctive "types" of lead were circulating simultaneously in the late Republic or early Empire. See above, p. 12, for characteristics of lead derived from litharge.
[539] Herchend 1995, 278-9.

perhaps there was prestige for the producer in simply being recognized. In the Republican period, however, with so many producers with ties in central Italy, there is the possibility that the ingots were being shipped back to family interests there for distribution, and the names were intended for ease of identification by receiving agents.

The symbols used in mold marks in this period are primarily restricted to anchors, dolphins and caducei. Their use shows no correlation with the names attested, with many different producers using the same symbols, and no consistency of use within an individual producer's output. These same symbols were also commonly found on amphorae and may have been indicative of an individual or family, a certain trade, or even propitious symbols to bring luck to the consumer or merchant.[540] Domergue notes a coin from Cartagena which bore a dolphin, thus this symbol might have had a specific connection to that city.[541] The use of civic symbols on coins and amphorae was a relatively common practice, which may have been adopted in the lead industry.[542]

Secondary markings are rare on Republican ingots. Stamps of a single name or initials were found on ingots from only seven Republican period wrecks in this catalog (**16**, **19**, **21, 26, 36** and **37**), and in no case was more than one present; no freehand weight marks were reported. While it is possible secondary marks have been underreported in favor of the more prominent mold marks, particularly in older publications, nevertheless their relative absence from the literature cannot be attributed entirely to modern analytical bias. The lack of such marks may be an indication that the strict bureaucratic control over distribution, so evident in the Imperial period, is only in its nascent stage. It also may indicate that the ingots did not pass through as many hands before beginning their journey by sea.

Ingots from this period consistently weigh in the range of 100 *librae* (33 kg). Salvi points out that this was the legal limit of what a single slave was allowed to

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[540] Various suggestions for individuals represented include potters, vintners, landowners, magistrates and shipowners. See *LLGS* (189) for similarities with symbols on lead.
[541] Domergue 1965, 19 n. 2.
[542] Garlan (1992, 243) provides several examples where civic emblems found on major coin issues were also used on amphorae produced in that city (e.g. a rose in Rhodes, and a griffin in Abdera), but warns on the risks of linking a symbol exclusively to a specific city.

carry,[543] but the standard might also have been related to taxation practices.[544] This standard carries over into the imperial period when it is used frequently but not exclusively. The strict use of the 100-*libra* standard in the first century B.C.E. is evidenced by examples from Cartagena-Mazarrón only, thus adherence to a single standard might have been enforced by local tradition or internal regulation rather than direct decree from Rome.

Lead Producers

The inscriptions from this period are primarily names of private individuals, or two individuals in partnership, with occasional business partnerships. Nearly all of the individual names in mold marks use the *tria nomina* standard employed only by Roman citizens,[545] although a few freedmen are also present. The family names attested on ingots from underwater sites of this period are listed in Table 5.6 along with the number of sites at which they were found. Based on the 1009 legible republican inscriptions from 18 sites recorded in Appendix A, only 20 families or partnerships are represented. The family names found most frequently are Planius, Utius, Atellius, Aquinius, Carulius and Pontilienus. Of these, at least three can be linked to the tribe Menenia,[546] whose territory comprised portions of Campania and southern Latium around the Bay of Naples.[547] Overall, however, very little is known of the individuals attested in the mold

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[543] Istituto Nazionale di Fisica Nucleare 2010.

[544] Domergue and Liou (1997, 17) note that tax regulations from Asia (*lex portorii Asiae*), dating to ca. 75 B.C.E., specify an export tax of 4 asses per 100 pounds on mineral exports, and suggest a similar taxation structure was used in Hispania.

[545] Citizens were generally designated by a personal name (*praenomen*) followed by the family name (*nomen*) and a third name (*cognomen*), originally a characteristic of the individual but later simply inherited from a direct ancestor thus denoting a specific branch of a family. The lack of cognomina in ingot stamps, such as C. VTI C.F. (**18.1**), is sometimes used to propose an earlier date than others, since the use of the cognomen becomes widespread only during the late Republic. However, this is a gradual change with no strictly datable trends, and since all of the ingots in question are from the last century of the Republic, there is little to be gained from applying this dating method. The use of *tria nomina* in conjunction with tribal affiliations is frequently used as a *terminus post quem* for inscribed Republican ingots, as the Italian tribes were not enfranchised until the end of the Social Wars in 88 B.C.E.

[546] Utius, Atellius, Carulius

[547] Domergue (1990: 321-2) records 23 family names from Republican ingots from both underwater and land sites, of which 12 are traceable to central Italy, of which at least 7 are linked to Campania - Atellius, Carulius, Messius, Nona, Planius, Seius and Utius.

Table 5.6. Family names (*gentes*) attested on Republican ingots included in Appendix A.

Gens	# of Sites	Complete Inscription	Catalog Number	Total ingots
Planius	9	L·PLANI·L·F·RVSSINI	16.2	1
		L·PLANI·L·F // *dolphin* // RVSSINI	17.3, 21.7, 27.14-15, 30.14, 31.1	6
		L·PLANI L·F RVSSINI // anchor	20.9-10	2
		L·PLAANI·LF // RVSSINI	28.1	1
		M PLANI L·F // *dolphin* // RVSSINI	20.2, 20.5-8, 25.3	6
Utius	6	C·VTI·C·F·MENEN	22.1-2	2
		C·VTIVS·C·F	18.1, 23.3, 26.1, 27.13	4
		VTIVS // dolphin	21.5	1
Atellius	4	CN·ATELLI·T·F·MENE	20.3-4, 20.11	3
		CNATELLITFMEN	21.6	1
		CN·ATELLI·CN·L·BVLIO	22.3-4, 25.2	3
Aquinius	3	C·AQVINI·M·F	17.1-2, 30.2-13	14
		M·AQVINI·C·F	27.1-10	10
Carulius	3	L·CARVLI·L·F[·]HISPALLI·MEN	23.2, 32.1	2
		L·CARVLI·L·F·HISPALI·MN	21.4	54
Pontilienus	2	SOC·MC·PONTILIENORVM M·F	16.4-6, 21.1	731+
		M·C·PONTILIENORUM·M·F	21.2	66+
Apinarius	1	Ṃ. APINARI M.F.	21.9	1
Appius	1	Q·APPI // dolphin // C•F anchor	21.3	83
Appuleius	1	L·APPVLEI·L·L·PILON	21.8	1
Calvus	1	M·SEX·CALVI·M·F.(?)	27.11	1
Cerdo	1	CERDO	37.1	7
Fiduius/Lucretius	1	C·FIDVI·C F // S•L[VC]RETI•S•F	30.1	1
Furi	1	A·P·FVRIEIS·C·P·L·L	35.1	1
Gariglius/Laetilius	1	Ḷ. GARGILI T.F. ẸT M. ḶAEṬỊḶI M.L.	16.3	1
Messius	1	C·MẸṢṢI·Ḷ·F	27.12	1
Octavianus?	1	M·OCT·M·L·PAPIL	25.1	1
Seius	1	Q SEI·P·F·MEN POSTVMI	19.1	1

marks. In some cases, members of the same *gens* are attested in other contexts in Cartagena, giving the general impression of relatively high social standing in the local community. A member of the Laetilius family, for instance, was a *duumvir* there and appeared on coinage of the city.[548] Others, such as members of the Atellius family, can be presumed wealthy based on the number of their freedmen attested in the city.[549]

Based on the recurrence of certain family names at multiple sites, one gets a picture of a limited number of wealthy Roman families dominating lead production in the Cartagena-Mazarrón region, with several smaller producers operating more or less at the same time. In most cases, the ingots can only be broadly dated to a time period of several decades. As with modern businesses, it is safe to assume that not all of these producers stayed in business that entire time; however, there is not enough evidence to construct a more nuanced historical framework for these ingots.

ROMAN EMPIRE (31 B.C.E. – 476 C.E.)

The greatest number of underwater lead ingot finds comes from the imperial period. Of the 27 sites I have attributed to this period (Table 5.7), the largest group is located around the mouth of the Rhone river, west of Massalia (**54**, **55**, **60**, **62**, **64**). Four were found in the Straits of Bonifacio (**45**, **46**, **47**, **48**), most likely en route to Rome or the Bay of Naples. Three (**40**, **41**, **56**) were found further west on this sailing route in the Balearic Islands. Increased lead circulation can be detected in the Adriatic, as well, primarily in connection with raw materials (**39**, **52**, **53,** and possibly **66**). This period also provides us the first examples of ingots on the Levantine coast since the Bronze Age (**59**, **65**).

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[548] Beltrán 1947, 208; *LLGS* 185.

[549] Cf. Domergue 1990, Table 14. Families with freedmen attested on lead ingots include the Atellius family (Bulio) (**22.3-4**, **25.2**), Laetilius (Marcus) (**16.3**), Appuleius (Lucius) (**21.8**), and Furieis (**35.1**).

Table 5.7. Roman Imperial wrecks containing lead products.

Roman Imperial Wrecks (27)				
No.	**Wreck**	**Region**	**Lead component**	**Cargo Category**
39	Comacchio	Emilia Romagna	102 ingots	raw materials
40	Cabrera D	Balearic Islands	several tons	staples
41	Cabrera E	Balearic Islands	43 ingots	staples
42	Cadiz D	Andalucía	1 ingot	staples?
43	Cartagena A	Murcia	30-50 ingots	isolated
44	Cherchel	Tipaza	Several	isolated
45	Sud Perduto B	Strait of Bonifacio	48 ingots	staples
46	Rena Maiore	Strait of Bonifacio	not specified	primary metal
47	Sud Lavezzi B	Strait of Bonifacio	97 ingots	staples
48	Lavezzi A	Strait of Bonifacio	5 ingots	staples
49	Les Sorres C	Catalonia	ca. 20 ingots	staples?
50	Ile Rousse	Western Corsica	1 ingots	stores
51	Port Vendres B	Pyrénées-Orientales	3 ingots	staples
52	Mljet	Dalmatia	lead minerals	raw materials
53	Istria	Istria	unknown	primary metal
54	Baie de l'Amitié	Hérault	98 ingots	staples
55	Marseillan Plage B	Hérault	17 ingots	staples
56	Ses Salines	Balearic Islands	50+ ingots	staples
57	Sancti Petri	Andalucía	18 ingots	primary metal?
58	Runcorn	Cheshire	20 ingots	isolated
59	Caesarea	Haifa	6 ingots	stores
60	Saint-Maries-de-la-Mer 1	Bouches-du-Rhône	100 ingots	primary metal?
61	Porto Pistis	Western Sardinia	40+ ingots	isolated
62	Saint Gervais A	Bouches-du-Rhône	4 ingots	stores
63	Ploumanac'h	Malban	271 ingots	primary metal
64	Le Petit Rhone	Bouches-du-Rhône	6 ingots	isolated
65	Dor	Haifa	4 ingots	stores?

The most common cargo type in the period (Fig. 5.9) is the staple cargo of Baetican-grown agricultural goods heading toward Rome, reversing the trend of the previous period, when Italian foodstuffs were moving into colonial areas. Several wrecks (**46**, **53, 60, 63**) have been classified here as new metal cargoes based on the quantity of

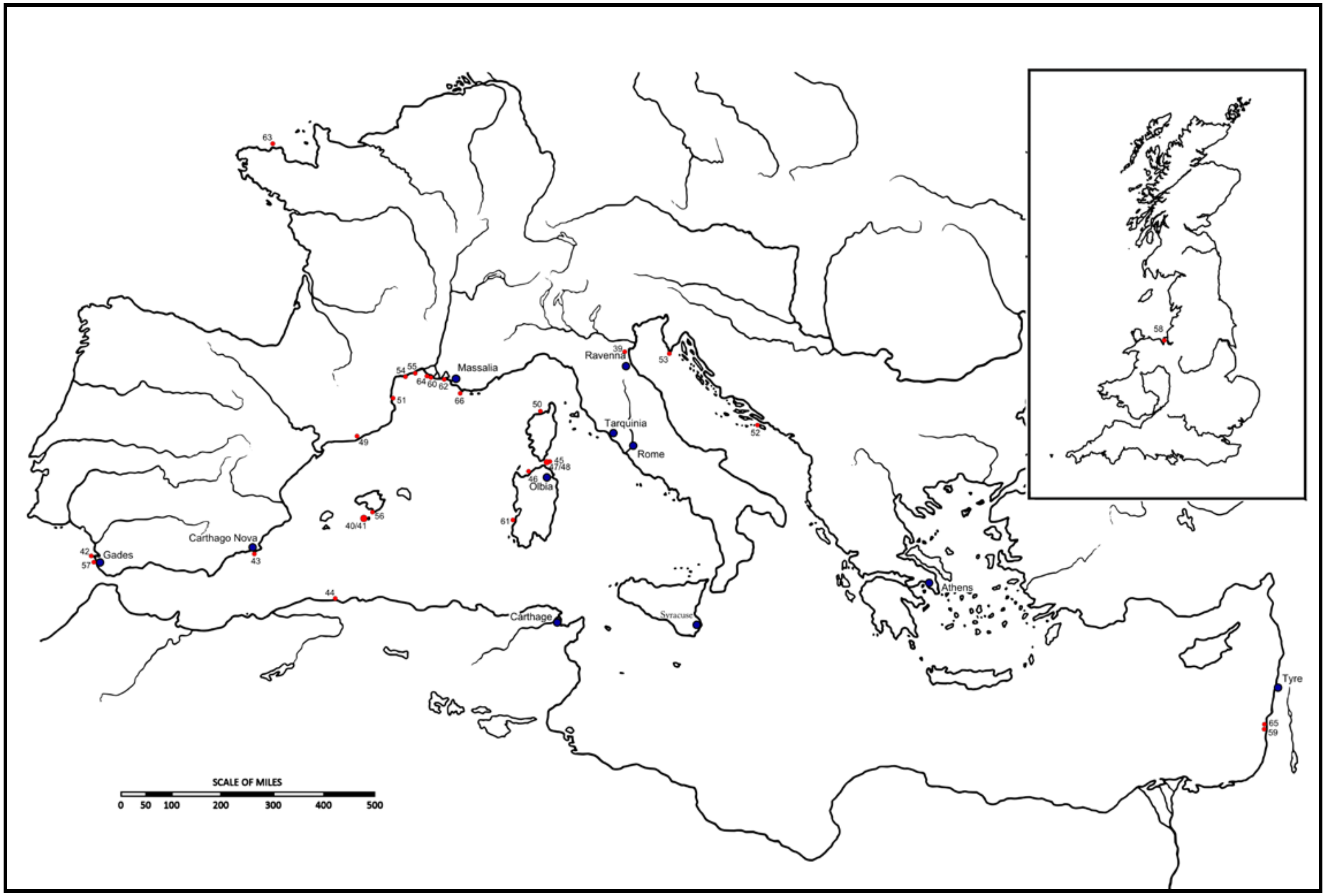

Fig. 5.8. Roman Imperial sites listed in Table 5.7.

ingots on board. The Sancti Petri wreck (**57**) has also been tentatively identifed as a new metal cargo based on context. While only 18 ingots were recovered from the site, they were accompanied by 28 copper ingots, suggesting a cargo of mixed new metals. Excavation of the site was cut short due to its location in a military test firing zone, but it is believed further ingots remain unrecovered.[550] It must be acknowledged, however, that if we were to have access to the full cargo manifest, some of these wrecks would be reclassified as raw material cargoes such as the Comacchio wreck (**39**), which was carrying over 100 ingots with plenty of room for a significant quantity of gravel, boxwood logs, and amphorae.

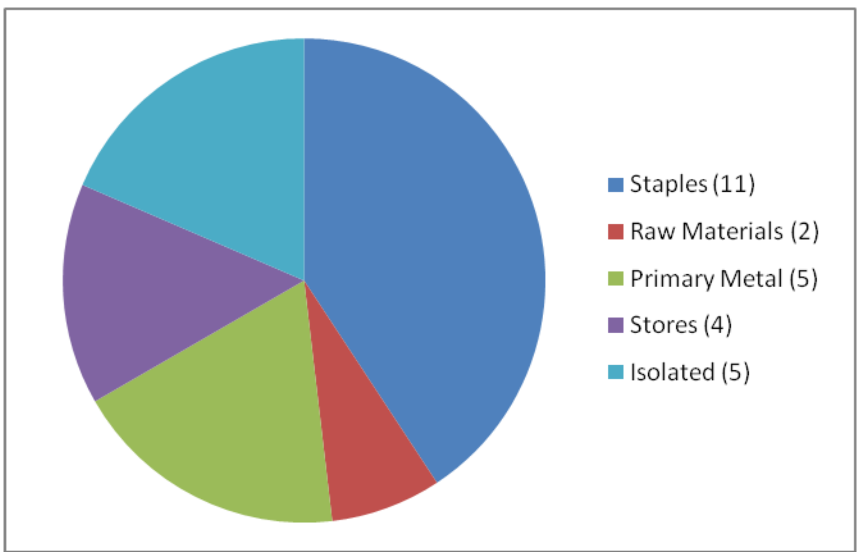

Fig. 5.9. Types of lead cargoes discovered in Imperial wrecks.

Only two raw material cargoes have been documented, each of a very different type. The materials found in the Comacchio wreck (**39**) appear to have been coming from the west, perhaps supplying the city of Ravenna or perhaps intended for the fleet stationed nearby at the newly-established naval base in the adjacent harbor. The Mljet wreck (**52**), on the other hand, contained amphorae, a consignment of tableware, along

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[550] Vallespín-Gómez 1986, 322.

with lead minerals, raw glass, and possibly alum, [551] suggesting this cargo was intended for relatively well-developed production center with professional artisans.

Fewer cases of ship's stores have been found, possibly reflecting the overall decline in the use of lead anchors and sheathing in this period,[552] or perhaps an increased availability of lead at distant ports, allowing captains to reduce supplies onboard.

Chronologically, most of the ingots found date to the first and second centuries C.E., though a few examples seem to represent later production (**63**, **64**, **65**). This is consistent with the overall pattern of shipwrecks in the Mediterranean, wherein the early empire represents the peak of ship-borne trade in the ancient Mediterranean, not to be reached again until the Middle Ages.[553] Lead use also peaks during this period, with widespread new settlement throughout the frontiers of the empire driving demand over a broad geographical range.

Origins

Although many of the ingot cargoes from this period appear to have come from ores in the Sierra Morena region of Spain, there is no such monopoly on the metal as we see in the Republican period. Production in Cartagena sharply declines in the early first century C.E.[554] The city itself flourished during this period with increased agricultural production attested in the archaeological record.[555] The very success of the city may have led to a decline in mining, as expensive villas encroached on polluting industrial areas; however, it is more likely that the veins had gone so deep by this point that there were more economical mining alternatives elsewhere.

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[551] A red lead oxide (Pb_3O_4), lead carbonate ($PbCO_3$) for white pigment, and lead sulfide (PbS) were all present (Radic-Rossi 2005, 34).

[552] But see Rosen and Galili (2007) on the many shipboard implements of lead that were still common in the early empire.

[553] Parker 1992a, 8.

[554] Until recently it was believed that lead production ceased there entirely at the end of the first century B.C.E. but a cargo of ingots from the Baie de l'Amitié wreck (**54**), dated to the second half of the first century C.E., has been linked isotopically with Cartagena-Mazarrón ores.

[555] Orejas andSánchez-Placencia 2002, 586-9.

Hundreds of lead-silver mines dotted the hills of the Sierra Morena in southwestern Spain in this period.[556] This region, part of the Roman province of Baetica, lies significantly inland, connected to the coast by the Guadalquivir river which meets the sea by the large port of Cadiz.[557] By the first century C.E., Baetica was a major exporter of wine, oil, and *garum* (fish sauce) in addition to the copper, silver and lead coming down river from the mountains. Cargoes of lead ingots and Baetican agricultural staples, sometimes accompanied by a consignment of additional metals, such as copper or tin, are a distinctive feature of the early Imperial period (**40**, **45**, **47**, **48**, **51**, **54**, **55**, **56**).

Two circumstances influenced shifts in the exploitation of lead ores in this period: First, as lead use reached its peak, lead ores began to be exploited for the sake of lead, with no significant silver content. In discussing the origins of minium, Pliny mentions silver and lead mines separately, which suggests the latter were not producing silver.[558] Thus, it was that Britain became a major source of the base metal without being a significant resource for silver. By the second half of the first century C.E. Pliny remarked that lead still could be mined in Spain and also Gaul with difficulty, but it was abundant at surface levels in Britain.[559]

Second, the expansion of the frontier further and further from the Mediterranean coast made importation from Iberian sources impractical. By the second half of the first century C.E., local and regional exploitation became noticeable, serving markets further out on the frontier and minimizing long distance transport as much as possible. Numerous Romano-British ingots from this period, from a wide variety of sites in that region, indicate that they were fully able to supply their own needs.[560] Ingots found at

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[556] See Domergue (1990, 44-49) for a complete list of known mines in this region.
[557] Previously part of Hispania Ulterior, the region was designated Hispania Baetica in 14 B.C.E., with the remainder of the former province to the north and west reallocated into Lusitania.
[558] Plin. *HN* 33.119.
[559] Plin. *HN* 34.164. This apparently disrupted the status quo to such an extent that a law was put in place to limit the amount of lead produced in Britain, discussed further below.
[560] *RIB* 2404.1-72.

Caesarea (**59**) appear to have been produced in Moesia Superior.[561] A study of the lead artifacts in Germany show that the Eifel mountains near the Rhine were also a significant source of lead in Germania from the first to fourth centuries C.E.[562] The Saintes-Maries-de-la-Mer 1 wreck (**60**) carried a sizeable cargo of lead ingots, most likely produced in west central Germany, into Mediterranean waters.[563] The mines of Sardinia were also producing lead in this period, as attested by the ingots from Porto Pistis (**61**),[564] which may represent the reopening of mines neglected during the late Republic.

The abundance of Roman ingots found in Britain and the scholarship devoted to the subject should not disguise the fact that lead mining and processing was taking place all across the empire. As the frontier expanded further from easy coastal routes and new ore deposits were acquired through conquest, reliance on Spanish sources waned. Demand for lead was high not just in Rome, but also in the far-flung military camps and the cities and villas that sprang up in their wake. If there were local lead sources available, that was typically the first choice; if demand exceeded local supply, only then was it necessary to import metal.[565] It is likely, however, that Baetica remained a predominant supplier to the markets of central Italy.

Ingot Characteristics

Ingots in the Imperial period are similar in size and shape to those of the Republican period. There are a few notable changes, however. The truncated pyramidal shape (D4) becomes increasingly common. Its wider top surface perhaps allowed for an increase in weight without as significant an increase in dimensions as the older, more triangular shape, which would have had become significantly higher as weight was

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[561] The original ore, however, may have come from Macedonia or Thrace, even though the ingots inscriptions indicate they were cast in Dardanica (Raban 1999, 187).
[562] Durali-Mueller et al. 2007.
[563] The ingots were originally assumed to have come from Spain, as their shape and inscription style was consistent with others from that area, but lead isotope analysis has ruled out that origin, instead linking them either with ores from southern France (Trincherini et al. 2001) or Germany (Rothenhöfer 2003, 280).
[564] Pinarelli et al. 1995, 85.
[565] Durali-Mueller et al. (2007, 1566), for instance, note that in the third century C.E., British lead appears to have supplemented local German sources.

added. This increase in dorsal surface area also led to both larger cartouches and larger letters in mold marks. Some second-century C.E. ingots bear mold marks not just on the back, but also on the front or rear face.[566]

Unlike the previous period, there is also an abundance of secondary inscriptions, both stamps and freehand marks, although punched inscriptions are rare. The typical lead ingot of this period bears a mold mark in a cartouche on the back; at least one stamp, but often more, on the end, base or one of the faces, containing a partial name or initials; and freehand numerals on one of the faces. Such a variety of marks is also frequently seen on amphorae of the period, attesting to an increased sophistication in the information being conveyed on commercial items.

Care must be taken in interpreting commercial inscriptions of this period. A great number of items had pre-production marks, such as amphorae, bricks, tiles, and lead pipes (*fistulae*), while post-production marks were common on trade amphorae.[567] The purposes behind these marks, however, appear to have varied depending on the types of items being marked. *Fistulae* often bore names of a government official, frequently in conjunction with the emperor's name and sometimes a manufacturer's name, suggesting the stamps were related to the oversight of imperial conduits.[568] Bricks and tiles often carried the names of the producer, either private or legionary, but their purpose remains unclear. Suggestions include a guarantee of quality, a method of marking lots to keep track of output, proof of exemption from taxes, and a deterrent against theft or unauthorized use of government property.[569]

Baetican amphorae seem to supply the closest parallel to the types of marks found on lead ingots. *Tituli picti* found on amphorae of the period conveyed a variety of information which appears to have been intended for different audiences, including

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[566] *RIB* 2404.4-10, 2404.31-2, 2404.34, 2404.59-62, 2404.66; some have molded symbols, usually a palm branch: 2404.16 (on each end), 2404.28 (on front and rear faces), 2404.29-30 (on rear face). Mold marks on faces are not generally enclosed in a cartouche.
[567] Since many of these were painted, it is possible that examples from earlier periods have had lower survival rates.
[568] Bruun 1991, 24-32. Private names are less commonly attested, and are believed to represent wealthy individuals with private water grants (see Bruun 1991, 63ff).
[569] Kurzmann 2006, 30-1.

government officials, merchants, and the consumer. Heinrich Dressel, in his study of the inscriptions from Monte Testaccio in Rome, classified the post-production inscriptions into four main categories of painted marks: α) a numeral on the neck, most likely representing the weight of the empty container; β) located below α, a name in capital letters, usually a *tria nomina*, originally thought to represent the maker of the contents of the container but later interpreted as the *mercator* or *navicularius* handling the transport or trade of the amphora; γ) a number painted in the middle of the belly, perhaps the weight of the contents of the container; δ) on the handle, vertically, a lengthy inscription in cursive that often included the port of embarkation, a consular year and a barred R whose meaning is debated.[570] There was also frequently a freehand numeral (ε) incised below the handle which may have been a serial number for a single consignment.[571] Despite the obvious differences between painted marks on a container bearing agricultural commodities and impressed stamps on a block of raw metal, details such as weight and merchant identification are found on both, evidence of the similar steps they must have followed from production point to consumer.

Mold Marks

The majority of mold marks of the Julio-Claudian period (31 B.C.E. – 68 C.E.) continue to carry the name of individual citizens. Several examples of imperial mold marks may date to the reign of Augustus or Tiberius;[572] however, by the time of the Flavian emperors (69-96 C.E.), ingots with imperial names begin to outnumber incidences of private individuals. Partnerships are almost entirely absent on surviving

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570 This summary of Dressel's classifications was taken from Colls et al. (1977, 50-1). Proposed interpretations for the barred R include *recognitum* and *recensitum.*
571 Frank 1936, 87.
572 The wreck at Rena Maiore (**46**) contained a batch of ingots marked AVGVSTI CAESARIS GERMANICVM, which appear to be connected to Augustan-era production in Germany (Eck 2004, 20-1; see also Appendix B on issues related to term GERM). An ingot from Ile Rousse bearing the imperial inscription CAESAR AVG IMP GERM TFCF (**50.1**) has been interpreted by some as referencing the emperor Caligula (Gaius Caesar Augustus Germanicus), but may also be seen to pertain to Augustus. Several isolated ingots from land sites in Britain also attest Tiberius Claudius (*RIB* 2404.01) and Nero (R*IB* 2404.03); a third ingot (*RIB* 2404.02*)*, often linked to Britannicus, son of Claudius, is now thought to be a geographical reference and therefore cannot be closely dated.

Mediterranean examples.[573] Several inscriptions appeal directly to the consumer (e.g. *EMPTOR SALVE* on **45.42-48)**,[574] a trend paralleled to some extent on amphorae on which *tituli picti* sometimes boast of the quality of their contents.[575]

In addition to changes in content, stylistic developments are also apparent in mold marks, such as ansate cartouches, found on ingots from Caesarea (**59.1-3**), as well as several land finds from Britain.[576] This motif also appears in contemporary inscriptions in other media, such as legionary brick stamps,[577] and may be indicative of legionary or state production. There is also a broader variety of symbols, including ivy leaves, palm leaves, lyres, rudders, and dolia, in addition to the anchors and dolphins seen in the republican period.[578] One ingot has more symbols than letters (**56.13**) and could conceivably represent some sort of word puzzle on the part of the producer.[579] One significant cargo from Baie de l'Amitié (**54**) consisted of ingots with only symbolic mold marks, and no letters at all. This level of ornate display might be linked to intensified commercialism in the private sector, in contrast to ingots with imperial mold marks, which are relatively unadorned. On the other hand, the most ornate ingots yet found come from the Rena Maiore wreck (**46**), which also contained ingots with imperial mold marks. If these decorated ingots belonged to the emperor, the decorative elements seen on private ingots may have been in emulation of these elite pieces.

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[573] The use of the term SOC (*RIB* 2404.5-6, 2404.13, 2404.55, 2404.58), SOCIOR (*RIB* 2404.53-4, 2404.57) and SOCIORVM (*RIB* 2404.59-60), usually in conjunction with a geographic or tribal name, is relatively common on second century C.E. ingots from Britain, but rare among Mediterranean underwater finds.

[574] See also **45.39-41**, which bear the regrettably incomplete inscription "*EMPTOR·EME·G·AV*[….]," apparently a command to the buyer to buy this ingot of an unknown Gaius.

[575] For example, two Haltern 70 amphorae from the Port Vendres B wreck (**51**) proclaimed their contents as "*DEFR(utum) EXCEL(lens)*" (Colls et al. 1977, 71, 78 and Fig. 21). The authors (1977, n. 205) also cite a similar inscription from Pompeii (*CIL* IV 5585).

[576] *RIB* 2404.17-18, 2404.40.

[577] See Kurzmann 2006, Figs. 33-35 (all dating to the late 1st century C.E.). Whether this style can be linked consistently to military production requires further research.

[578] Due to the state of preservation of some ingots and the relatively rudimentary shapes represented, interpretation of these symbols tends to be somewhat subjective and disagreements can arise as to the identification of some symbols; however, the increased variety of symbols in this period is still a real phenomenon. For illustrated examples, see Colls et al. (1986, Fig. 9) re Cabrera E (**41**) and Bernard and Domergue (1991, Fig. 8) re Sud Perduto B (**45**).

[579] Given the complex monograms that appear to have developed in the secondary stamps in this period, discussed below, this is not an unreasonable suggestion.

Post-Production Marks

Post-production marks on ingots increase in frequency and diversify in the Roman Imperial period. Stamps with names, initials or imperial designations are common. In some cases, two different stamps can be combined to form a full *tria nomina*. This practice likely developed due to the difficulties of successfully stamping a string longer than approximately 5 letters; differences in pressure upon application often left a deeper, more legible impression at one end, with lighter, less legible letters at the other end. When two stamps consistently appear together on the same face on a set of ingots, it can indicate that they represent a single individual.[580] Some secondary stamps refer to an emperor rather than a private individual, and these too were sometimes split into two separate dies, such as the IMP CAES // VESP AVG stamps from Ses Salines (**56**). There are also several examples of stamps that apparently consist of three initials in a single stylized ligature, creating essentially a unique symbol representing an individual.[581] This is a rare phenomenon and cannot be said to be characteristic of Imperial ingots.

The individuals represented in secondary stamps were initially interpreted by scholars as state officials.[582] This may have arisen in part by analogy with Roman copper ingots, many of which bear secondary marks referencing a procurator or vice procurator.[583] With the opportunity afforded by underwater discoveries to study large cargoes of contemporaneous ingots, analysis of the order, placement, and frequency of stamping suggests the stamps were those of private individuals. The currently-accepted

[580] Bernard and Domergue (1991, 51) outline their case for this interpretation as applied to the C. CACI // PHILARG stamps from Sud Perduto B (**45.1-25**) with the following points: 1) the two stamps are approximately the same size; 2) they are always stamped on the same side of the ingot and close to each other; 3) in the three cases of overstrikes, PHILARG was twice struck over C.CACI, and once it was the other way around, indicating that both stamps were applied at the same time.
[581] These all come from the Commachio wreck (**39**; see Fig. A.2) and this interpretation, proposed by Domergue et al. (2006, 6-10), is not certain.
[582] Parker (1974, 149), for instance, speaking of the imperial secondary stamps on the ingots from Ses Salines (**56**), states: “The fact that these stamps were applied before the weight was inscribed on the ingots suggests that they represent some official control, perhaps of fineness, or perhaps of port passage.” However, imperial secondary stamps are now known to be rare, so this cannot represent a regular procedure.
[583] E.g., Euzennat 1971.

view is that secondary stamps represent the names of merchants purchasing ingots either directly from the producer or from another merchant.[584]

Freehand marks are most commonly numerals associated with weight, and often represent simply the number of *librae* above or below a particular standard (usually 100 *librae*) the ingot weighs.[585] In rare cases, however, freehand numerals may represent numbers in a series that acts as a batch count.[586] Weight marks on ingots from Caesarea (**59.1-4**) are relief stamped using a series of dies, one for each numeral, functioning almost like movable type.[587]

Analysis of the post-production marks from several of the Spanish cargoes has shown that the freehand numerals were often made after the first set of secondary stamps, and after nail holes possibly tied to river transport, indicating they were not made at the production site.[588] Domergue interprets the application of the weight marks at so late a stage as being necessitated by the calculation of harbor duties by government officials in the port of export, while at the same time, being useful to *navicularii* to calculate shipping costs.[589] It is also possible these marks were made by the merchant upon sale as part of the determination of price. However, the fact that there are weight marks on ingots with imperial primary stamps from Ile Rousse (**50**) and Caesarea (**59**), as well as those with imperial secondary stamps from Ses Salines (**56**) and Saintes-Maries-de-la-Mer (**60**), which were presumably not taxed nor sold on the open market, may indicate the weight marks had a different or additional purpose, such as for those transporting the ingots to calculate the total burden.

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[584] Domergue 1998, 203.
[585] Domergue 1998, 203. Domergue and Liou (1997, 12) report finding only a dozen cases, all from copper ingots, where numerals appear to represent actual ingot weights. These ingots came from only three sites: Planier 2, Marseillan, and Riches Dunes [also known as Marseillan Plage B (**55**)].
[586] This has been suggested for the ingots from Porto Pistis (**61**) (Zucca 1991).
[587] For instance, the full inscription on **59.2** reads: CAES / CC / X / V; the ingot weighs 70.2 kg or 214.7 *librae* (Raban 1999, 183). The fact that 'CC' is contained on a single die indicates 200 was a commonly-used value and may reflect a 200-*libra* standard.
[588] Domergue 1998, 203-4.
[589] Domergue 1998, 208-9.

Weight Standards

An increase in average ingot mass is clearly detectable in this period (Table 5.8). Weights within batches usually conform to the same standard, regardless of the number of producers attested, suggesting there were regional standards. Based on freehand marks, it appears that in Hispania, at least, the 100-*libra* standard was maintained for weighing even though many ingots are noticeably heavier (**45**, **47**, **51**). The one known batch of ingots produced in Sardinia (**61**) was also weighed against a 100-*libra* standard. Thus ports closest to Rome seem to have maintained Republican merchant standards, even though some producers no longer cast to that standard.

The ingots from Saintes-Maries-de-la-Mer 1 (**60**), produced in Germany, reflect two different standards – 120 and 140 *librae*.[590] Despite the different standards, their actual weight averaged approximately 54 kg, which is very close to the actual weight of the three Spanish sets listed above. It is possible that under the early empire a commonly-accepted trade weight developed that no longer conformed to long-standing weighing standards in Hispania. The fact that two different standards were represented in the shipment from Germania is unusual, and perhaps indicates they were separate batches, weighed in two different locations before making it to the ship that carried them to the Mediterranean.[591]

Two sets of ingots (**58**, **59**), both bearing imperial mold marks, have been found in underwater contexts outside of the western Mediterranean. These ingots likely originated, respectively, in Britain and Moesia Superior, and appear to have been cast to a 200-*libra* standard. The weight marks from the Caesarea (**59**) ingots, mentioned above, are so far unique in consisting of a series of relief stamps. The formality of stamping the

[590] Long and Domergue 1995, 829.

[591] All the ingots in 140-*libra* group are of type D4 and bear mold marks with the name L. Flavius Verucla; while the 120-*libra* are all of type D1.2 and bear only secondary marks, including that of L.FL.VERV.

numerals, combined with a secondary stamp that might signify a government official,[592] seems to indicate a highly regulated, government production site.[593]

Table 5.8. Weight standards attested in lead ingot cargoes of the Imperial period.

No.	**Wreck**	**No. of Ingots Analyzed**	**Weight Range (kg)**	**Average Weight (kg)**	**Average Weight (*libra*)**	**Standard (*libra*)**	**Mold Mark**
39	Comacchio	102	19.45 - 45.1	30.97	94.71	100	Civilian
40	Cabrera D	8	30 - 33.5	31.44	96.15	100	Civilian
41	Cabrera E	43	32.12 - 42.19	37.10	113.46	100	Civilian
45	Sud Perduto B	48	41.8 - 48.2	44.70	136.70	100	Civilian
47	Sud Lavezzi B	92	47.4 - 54.6	52.02	159.08	100	Civilian
56	Ses Salines	20	29.3 - 34	32.10	98.17	100	Civilian
58	Runcorn	1	68[a]	68	207.95	200	Imperial
59	Caesarea	4	54.7 - 71.1	64.2	196.33	200	Imperial
60	Saint-Maries 1 (D4)	8	52.4 - 55	53.79	164.50	140	Civilian
60	Saint-Maries 1 (D1)	91	46.4 - 68.2	54.17	165.66	120	*none*
61	Porto Pistis	8	33.5 - 39.5	37.31	114.10	100	Imperial

[a] weight inferred based on parallels from a different site; original weights not recorded

Many other ingots with imperial mold marks have been recovered from land sites in Britain with a similar weight range.[594] If the ingots were produced by military forces on the frontier, this may have been an official military standard. If the 100-*libra* standard was related to taxation, the imperial ingots were presumably exempt from taxation and

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[592] The stamp *SVBGCAL*, present on all four legible ingots, has been tentatively interpreted as "*under the supervision of Gaius Calpurnius"* (Raban 1999, 179).

[593] A second set of incised numerals, different from the stamped numerals, also appears on two of these ingots (**59.1-2**), suggesting they were weighed separately on at a subsequent point in the distribution chain. In one case (**59.2**), however, the freehand numerals do not appear to match the stamped numerals, raising some confusion (Raban 1999, 183).

[594] Among the many British ingots in this weight range in *RIB*, three ingots (2404.28 – 2404.30) with imperial mold marks (*IMP HADRIANI AVG*) are reported from Shropshire and Montgomeryshire, with the following weights: 86.3 kg, 86.64 kg, 86.2 kg; from the same region is an ingot of 86.27 kg (2404.31), which is stamped with imperial names but may be tied to municipal production, as discussed in the following section.

did not need to adhere to this standard.[595] However, if the 100-*libra* standard had been adopted, as has been suggested, as a legal maximum for slave labor,[596] the increase could be related to the overall decline of slave labor in this period accompanied by a shift toward imperially-controlled lead production perhaps employing military or local non-compulsory labor.

Lead Producers

A distinction can be made in this period between mold marks bearing the name of an emperor and those bearing the name of an individual, tribe or company, collectively designated "private" mold marks. It has been pointed out that mold marks bearing imperial names do not necessarily mean the ingots were produced at state mines or by state-controlled labor. Some ingots from Britain provide evidence that, in some cases, municipalities or individuals were processing the metal but producing ingots with imperial mold marks.[597] This is implied by certain inscriptions that bear an imperial mold mark on the back, but an additional mold mark on the front face, which may be interpreted as either a geographic identifier or a tribal designation.[598] In addition, two inscriptions use the imperial name as part of a consular date, which does not necessarily imply the ingots themselves were produced by the state;[599] one of these identified a legion, however, suggesting that some legions did engage in production of lead ingots, though whether they also mined the ore is another question.[600] In the majority of cases, however, the presence of imperial mold marks suggests that the ingots were property of the state or imperial family, although not necessarily produced by the state-controlled

[595] It must be noted that the Sardinian ingots from Porto Pistis (**61**) have imperial mold marks but retained the 100-*libra* standard.
[596] Istituto Nazionale de Fisica Nucleare 2010.
[597] Hirt 2010, 101-3.
[598] From the Mendip Hills, *RIB* 2404.4-10: *BRIT·EX ARG·VEB*; from Flintshire (Clwydd), 2404.31, 32 and 34: *DECEANGL*, on which the imperial mold mark is a consular date; from the Runcorn site (**58.2**), RIB 2404.36: *DECEANGL*, with a simple imperial name; and from Yorkshire, 2404.61-2: *BRIG*.
[599] *RIB* 2404.13 (*IMP VESP AVG VIIII BRIT EX AR*), and 2404.31 (*IMP VESP AVG V T IMP III CO[N]S*).
[600] If military personnel wanted to designate lead as state property, as has been suggested for legionary brick stamps, they may have recast lead acquired from private sources into ingots with imperial mold marks.

labor. In the two cases in which ingots with private mold marks have been marked with imperial secondary stamps,[601] it most likely indicates that they were property of the emperor or the state, but whether they were purchased or collected as tax or tribute is less clear.

Names of individuals are most commonly attested in mold marks on ingots originating in Spain and persist until the late first century C.E. Unlike the Republican period, there are no dominant names and only a few names appear at more than one site (Table 5.9). The name M. Valerius Ablo has been found at two underwater sites, Cabrera E (**41.35-6**) and Sud Perduto B (**43.33**). At the latter site the name L. Valerius Severus was also attested (**43.32**). Even though these two individuals share the same family name, the different *cognomen* makes it difficult to discern how closely tied they might have been. In both cargoes, there are a number of other lead producers represented, so they do not seem to have been dominating the market in any way. The name Q. Varius Hiberus, found on ingots at Cherchel (**44**), has been attested on another ingot, found on land, as well as coins from Cartagena.[602] This may represent one of the last of the politically high-ranking lead producers of the old Carthago Nova network system.

While personal names are primarily from Spanish contexts, some have also been found in terrestrial contexts in Britain. One region in particular, Lutudarum in modern Derbyshire, had a high incidence of mold marks attesting individual or company names rather than Imperial names.[603] The trend of referencing the mines of origin (MET LVT) on the ingots of this region is helpful in showing that both private and imperial stamps[604] were produced from the same ore body but we do not know whether they are contemporaneous or reflect changes in mine control over time. Nevertheless, it is apparent that in some regions at least, production of lead ingots was not always the sole purview of the state or the emperor.

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[601] Saintes-Maries-de-la-Mer 1 (**60**), which had both imperial and private secondary stamps, and Sud Perduto B (**56**), with only imperial stamps.

[602] Beltrán 1947, 208.

[603] RIB 2404.40: *L(uci) Aruconi Verecundi metal(li) Lutud(arensis)*; 2404.46-50: "*(ai) Iul(i) Proti Brit(annicum) Lut(udarense) ex arg(entariis)*; 2404.51: *P(ubli) Rubri Abascanti metalli Lutudare(n)s(is)*; and 2404.54-55, 57-58: *Socior(um) Lut(udarensium) Br(itannicum) ex arg(antariis)*,

[604] RIB 2404.39: *Imp(eratoris) Caes(aris) Hadriani Aug(usti) met(alli) Lut(udarensis)*.

Table 5.9. Non-imperial mold marks from lead ingots of the Imperial period from Appendix A.

Mold Mark*	Catalog Number	# of Ingots	Total ingots on wreck	Date	Wreck
SLON	40.1	1	"several tons"/21 published	1-15 C.E.	Cabrera D
AC… NAII	40.3	1			
ANTEROS // EROS	40.10	1			
SOC VESC	40.11	2			
L·IVNI DIVO	40.12	2			
T·L·OSCA	40.13	2			
Q·AELI / SATVLLI	41.1	1	43+	10 B.C.E. - 25 C.E.	Cabrera E
TANNIBER	41.2-5	4			
P·CAECILI POPILLI	41.6-8	3			
L·FLAC POM	41.9-15	7			
Q·HATERI GALLI	41.16	1			
HAVE IVLI VERNIO	41.17-24	8			
PLVMB CAI (or GALLI)	41.25	1			
PPOSTVMI RVFI	41.26-34	9			
M·VALERI ABLON	41.35-6	2			
….VS L·F·RVFVS	41.37-43	7			
P·NONAE P·F·NVC	43.1	1	30-50	50 B.C.E. - 50 C.E.	Cartagena A
Q·VARI HIBERI	44.1	1	"several"	25 B.C.E. - 75 C.E.	Cherchel
C·ASI…	45.1-2	2	48	1 - 15 C.E.	Sud Perduto B
M·H…..	45.3-.21	19			
G·VACALICI	45.26-31	5			
L·VALERI SEVERI	45.32	1			
M·VALERI ABLONIS	45.33	1			
dolphin rudder dolphin	45.34-7	4			
ANT // AN…	45.38	1			
EMPTOR EME G. AV…	45.39-41	3			
EMPTOR SALVE	45.42-.48	7			
..FLAVI VERVCLAE PLVMB GERM	60.1-.8	8	100	7 B.C.E. - 9 C.E.	St-Maries-de-la-Mer 1
MINVCIORVM	47.1-93	93	97	10 - 30 C.E.	Sud Lavezzi B
C….C..O….	48.3	1	5	1 - 50 C.E.	Lavezzi A

Table 5.9. Continued

Mold Mark*	Catalog Number	# of Ingots	Total ingots on wreck	Date	Wreck
P F… S….	48.4	1			
M·HELVI·M…AV	51.1-.3	3	3	42 - 48 C.E.	Port Vendres B
…EMILI GALLICI	56.1	1	50+ / 20 published (only 1 letter distinguishable on ingot 15)	69 - 79 C.E.	Ses Salines
NE MEVI APRI	56.2-.4, 56.20	4			
Q·CORNVTI	56.5-.7, 56.18-19	5			
L·MANLI	56.8-10	3			
C·M·A	56.11-.12	2			
SO VR	56.13-.14	2			
…..X	56.15	1			
A·VITI	56.16-.17	2			
CIVT BR GZINILI ZAL	63.1a	?	271+	3rd - 4th c. C.E.	Ploumanac'h
CIVTBR	63.1a	?			
CBRIGAN	63.1a	?			
CIVT ICIINP CCC	63.1b	?			
CIVTICCENORP	63.1b	?			
CIVT BRḌ SINILI[S]	63.1c	?			
SEGETI	63.1c	?			
TẠCLEMENTINI	63.1c	?			
CVNOVEN	63.1c	?			
CB C CIVILIS AL	63.1c	?			
LATINI	63.1c	?			
TVSCANI	63.1c	?			
MIVS	63.1d	ca. 80			

When one compares cargoes with private mold marks to those with imperial mold marks (Fig. 5.10), one can see that privately-attributed ingots are most commonly associated with staple cargoes, while imperial ingots are found most frequently as stores or in isolation, suggesting that imperial ingots in the Mediterranean were circulating as part of fleet or harbor activities, while private ingots were tied to commercial shipments. The large ingot cargo from Saintes-Maries-de-la-Mer (**60**) and the cargo of lead ingots combined with metallurgical processing material from Rena Maiore (**46**) may offer some insight into how state-owned lead supplies were shipped to the capital.

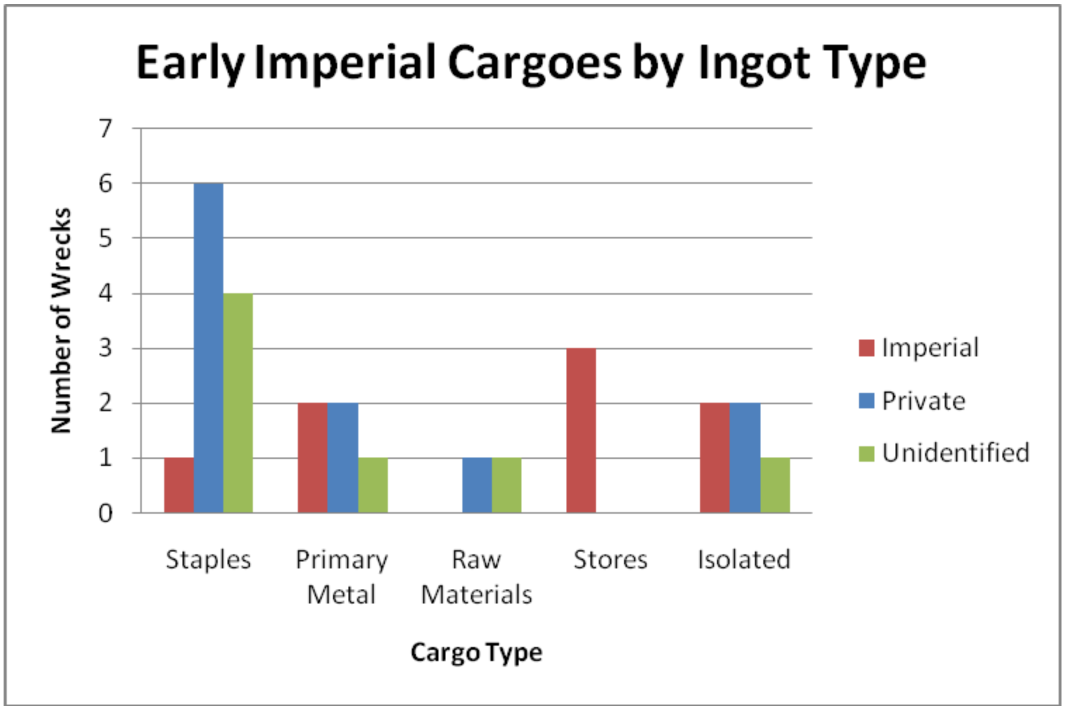

Fig 5.10. Imperial and private ingots by cargo type, based on wrecks from the first and second century C.E.

CONCLUSION

By examining ingots in context at underwater sites, one can gain a better understanding of the relative volume of lead cargoes, in what circumstances they were traded, and whether the lead can even be considered cargo. This information is important in attempting to discern the larger picture of commercial activity in the trade of lead and how it was tied to different markets and consumer behavior. Lead ingots were transported over great distances in the ancient world, indicating that lead was a significant commodity, but closer analysis of the archaeological contexts in which they were found can illuminate subtler patterns in ancient lead trade.

CHAPTER VI
CONCLUSION: PATTERNS OF DISTRIBUTION

Having examined the application, origins, and circulation of lead in the ancient world, it remains to comment briefly on the economic forces that drove the cycle of trade. Given that metals require a heavy initial investment in mining and production, there must always be sufficient demand to justify such expense, as well as people willing to undertake the risk and effort, either through necessity or hope for gain. Lead, with its relatively low value, was not a prestige good nor even an indispensible staple, but a utilitarian commodity with a wide range of consumers, both generalized and specialized.

An examination of the patterns of lead trade, from production to consumption, can illuminate the trade activity for an important class of goods - utilitarian raw materials, many of which, such as clay and timber, are underrepresented in the archaeological record. This sector of trade is one of moderate to small-scale entrepreneurship often tied to professional consumers, such as builders and artisans, who are themselves entrepreneurs. This cycle of trade is often lost due to emphasis on luxury goods and agricultural output, but, in terms of an overall assessment of the ancient economy, it bridges the gap between prestige trade and subsistence production.

In order to fully understand the economic forces of the lead trade, one must consider who controlled the mines, and in addition, who controlled the lead ore. The two are not necessarily the same. Due to its common occurrence with silver-rich ores, it is likely that close oversight of the ore, in cases of both state-owned and private mines, stopped with the extraction of silver. It is difficult to trace mine ownership even in well-documented periods, nevertheless, with the help of textual references, several scenarios can be reconstructed.

In cases where an organized state procured resources from a land not under their control, such as in Bronze Age Mesopotamia and Archaic Phoenicia, it would appear that the mines were owned and operated by indigenous people. How ownership was handled within the native population is less well understood, but output was apparently oriented toward trade with agents of the distant state through established trading centers. Documents from the second millennium B.C.E. concerning caravan trade between Assyria and Anatolia show a complex system of trade organized by the state and carried out by contracted merchants. Mario Liverani describes the system as follows: "trade agents got silver and/or processed materials (that is, mainly metals and textiles) from the central agency and had to bring back after six months or a year the equivalent in exotic products or raw materials." [605] The period during which they were out of the country and unsupervised left a great deal of room for private enterprise on a small to moderate scale. These documents primarily concern trade in tin and textiles for silver, thus we do not know if lead was handled in the same fashion. The presence of lead ingots at the palace workshop at Ras Ibn Hani[606] suggests that some effort was made by the state to import lead, although it was not likely to have been part of the elite gift exchanges that characterized trade in this period.[607] The presence of lead for cupellation at the fourth millennium B.C.E. site of Habuba Kabira[608] indicates that some lead was acquired by metallurgists in distant outposts as a tool of the silver trade and that this trade may have been outside of the palatial sphere.

A similar system of trade with native groups for refined metal is likely to have been the case for Phoenician traders of the Archaic period, although the merchants were not as clearly tied to the state.[609]

When mines lay within the territorial boundaries of the state, the land was usually claimed either by the ruler as royal property, or, in the case of republics such as Athens and Rome, as a public resource. An example of the former are the silver mines of Macedonia, which were in the possession of the king until the defeat of Perseus in 168 B.C.E.[610] Such enterprises were presumably run by agents of the king and depended in great part on compulsory labor.

[605] Liverani 2005, 52-4.
[606] Bounni et al. 1998, 48-9.
[607] An exception might be Egypt, which may have received lead as tribute from several northern kingdoms; see supra n. 249, for a further discussion.
[608] Pernicka et al. 1998.
[609] See discussion in Aubet (2001, 111-119).
[610] Livy 45.18.3 – 5.

Athens and Rome both leased out the working of mines on public lands to private individuals or partnerships, thus divesting the government of the responsibility of providing labor and equipment. It is likely that some of the mines around Cartagena were subsequently sold to private owners in the early to mid first century B.C.E.[611] No matter the arrangement, the state was owed a share of mine output either as rent or tax, while a significant share resided with the lessee. The second century C.E. *lex metallis dicta*, preserved in part on the second Vipasca tablet, states that lessees owed half their ore to the state, but that they could pay the state for that ore and keep it to process themselves.[612] This system would leave the lead material left behind from silver extraction in the hands of the lessees who could dispose of it as they saw fit. This was likely a common method for arranging the logistics of state-leased mines, as we know in the Classical period, the lead from Laurion was in private hands despite it originating from state-owned lands.[613]

Ingots from the Imperial period, with their imperial mold marks, appear to indicate that the state was running some operations directly, although the *lex metallis dicta* shows that leases to private individuals continued, at least in Spain. This shift toward more government control over lead may be related to the increased centralization of infrastructural development, such as water management, which could require large volumes of lead for state projects.[614]

From a consumption standpoint, recycling was also an important source of lead, particularly in periods or regions where access was restricted. Items in all use categories, from infrastructural to personal, might on occasion be derived from recycled

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[611] In a speech dated to 63 B.C.E., Cicero (*De leg. Agr*. 1.1.5 and 1.2.5) complains that the *ager publicus* of Carthago Nova had been sold off, though does not specifically mention the mines. Strabo (3.2.10), writing in the early first century C.E., specifically states that silver mines at Carthago Nova and elsewhere were in private hands, while gold mines belonged to the state.

[612] Domergue 1983, 115-6. According to Domergue (1983, 203), the first tablet, often called *Vipasca I*, was found in 1876 and contained many regulations for an Roman mining town in the Imperial period. The second tablet, *Vipasca II.*, was found in 1906, and contained many laws governing mining; it was first published in 1892, in *CIL* 2 (Suppl.) 789-90.

[613] Arist. [*Oec.*] 1353[a].

[614] The fact that in the late first century C.E. there were two gangs of *plumbarii* in Rome, one belonging to the state and one to the emperor (Front. *Aq*. 116), suggests supplies were also provided from state or imperial holdings.

materials.[615] Recycling was likely more practical for small-scale personal use rather than large-scale consumers needing a steady, reliable source of metal, though they might have supplemented regular supplies with recycled quantities when available. Certain professional consumers needing pure lead, such as makers of art bronzes or medical practitioners, most likely avoided metals from this source.

CARGOES AND MARKETS

The overall impression is that a large amount of lead appears to have been circulating through private hands in the ancient world. By examining the cargoes in which lead was found, we may be able to make further inferences about the nature of the trade being conducted. Using the cargo types outlined in the previous chapter, we can infer the type of trade they most likely represent.

Staple cargoes generally consist of agricultural goods, such as oil and wine, often with a small component of domestic ceramics, that are ready to be sold directly to an individual consumer. Thus, these cargoes most likely to represent inventory to be sold on the open market trade, either at an emporion or through opportunistic trade as a ship circulated from port to port.

Primary metal cargoes, such as that found at Mal di Ventre (**21**), more likely represent a pre-arranged, "directed" shipment to a single vendor. With building projects, military provisioning and water management contracted out to private enterprise during the Roman Republic,[616] it is possible that, even if this was a cargo of military supplies, as the excavator suggests,[617] the shipment represents a private transaction, arranged in advance without the metal ever being made available for public purchase. Other primary metal shipments may have been destined for a large market serving specialists, or, depending on the period, a state shipment. State cargoes can sometimes be discerned

[615] Incidents of lead recycling in ancient texts include Xenophon's account of soldiers gathering lead for sling bullets (*An.* 3.4.17), and Frontinus (*Aq.* 115) who estimates the amount of water illegally diverted by private citizens in Rome by the amount of lead confiscated by the state, implying that they would reuse it for official projects.
[616] Polybius 6.17. See also Brunt (1988, 148-9).
[617] Salvi 1995, 247.

through ingot inscriptions, such as the Saintes-Maries-de-la-Mer (**60**) ingots, but are otherwise difficult to detect.

Raw material cargoes were more likely to have been supplying a developing area, particularly if building materials were present, such as that on the Comacchio wreck (**39**). Cargoes with artisanal supplies, such that as the Mljet wreck (**52**), suggest a port with a significant density of craftspeople, where goods such as minerals and raw glass could be readily sold, perhaps a community large enough to support dedicated shops for such material. Thus, demand from the professional quarter might have been met in some cases by merchants who specialized in supplying raw materials.

The Phoenician cargo at Bajo de la Campana (**5**) contained a large number of elephant tusks, a particularly valuable commodity, which suggests that some raw material cargoes can be tied to prestige trade. In this case, the cargo may have been destined for artisans supported by an elite household or to a particularly wealthy merchant specializing in supplying luxury goods.

It is also possible that a shipment of raw materials was destined for a specific building project and not destined for subsequent redistribution. An example of this, from the stone trade, is the wreck of marble column drums from Kızılburun. This cargo consisted of a set of eight drums and Doric capital, along with additional, smaller marble pieces, including louteria and stelae, most likely bound for the Temple of Apollo at Claros.[618] Such a shipment may represent a special order from the temple for a variety of marble pieces needed for the site.[619] While this shipment consisted entirely of marble from a single quarry, other shipments of mixed building materials might as easily have been arranged by an agent to be shipped together to a project site.

Another factor to be considered in characterizing a cargo, is consistency within the lead cargo itself. Batches of inscribed ingots can be described as heterogeneous or homogeneous. The former consist of ingots with mold marks of more than one producer, while the latter contain only ingots from a single producer. A heterogeneous cargo,

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[618] Carlson and Aylward 2010.

[619] With only 8 drums out of a necessary 12, there was probably an additional ship carrying another portion of the order.

particularly one that bears secondary stamps of one private individual, such as the ingots from the Cabrera D wreck (**40**), would appear to represent a cargo selected and purchased by a merchant at a port close to a production area with a large supply of ingots on hand to choose from, and most likely represent standard open market activity.

When all ingots are from the same producer, it more likely represents a large-scale private transaction, possibly arranged directly with the producer, such as a dedicated shipment for a professional builder or *plumbarius* needing a significant quantity of lead. The Mal di Ventre (**21**) ingots are not all from the same producer, but the majority of the ingots (over 800) come from one producer (Marcus and Gaius Pontilienus). In this case the person to whom the ingots were being shipped may have had ties of family or patronage with the Pontilieni, who were asked to supply a certain amount of lead, which could not be met entirely from their on-hand supplies, so they made up the shortfall made from other supplies available in Cartagena.

This distinction cannot easily be made for uninscribed ingot cargoes, although if the ingots are all of the same type with relatively similar weights, homogeneity may be proposed, and tested with chemical analysis.

REVIEW AND CONCLUSION

By considering ancient lead ingots in relation to the cargoes of which they were a part and the uses common at the time of their production, we can see a shifting pattern of distribution dependent upon control over resources, territorial expansion, and types of demand. In the Bronze Age, lead had small-scale personal use, but more significant demand came from palatial workshops, both for architectural use as well as for refining silver.

Lead in the Archaic period was commonly circulating in mineral form as raw materials destined for further processing, most likely by professional craftspeople for pigments, cosmetics or, in the case of galena, for cupellation. There are also cargoes of finished goods circulating with lead ingots, some coming out of the Aegean, which may have been supplying colonial ports around the Mediterranean. If one can view the

Aegean as a locus of innovation in lead use, it is possible that demand for lead in the western Mediterranean was higher in the Greek colonies, where residents were more accustomed to a variety of domestic applications.

The Classical period finds one of the largest sources of lead under control of a democratic state. The structures in place for managing mineral resources left a large portion of lead in private hands. Based solely on the Porticello wreck (**9**), it appears that refined lead from Laurion continued to make its way into the western Mediterranean on ships supplying the colonies. Markets in the Near East may also have been supplied in part from increased Aegean production; however, lead ingot finds from this period are rare, and no large cargo has yet been found.

In the Hellenistic period, our main evidence comes from southern France and the Balearic Islands. The Punic ingots from Cala d'en Ferrer (**11**) attest to continued raw material acquisition from the Iberian peninsula by descendants of the Phoenician traders of the Archaic period. The presence of ingots from Sierra de Cartagena in the Agde K wreck (**12**), near Marseille, might be related to continued consumption in the Greek colony of Massalia, with supplies produced in the western Mediterranean. The decline in productivity at Laurion shifted dependence away from Attica, perhaps in favor of Macedonia in the East and Iberia in the West. With only four lead wrecks so far discovered in this period, one obtains a picture of small-scale market trade on merchant trading vessels visiting Punic, Greek, and Roman territories equally.[620] Future discoveries may help expand this picture.

Under the Roman Republic, lead ingots emerged as a standardized product in the early first century B.C.E. Inscriptions seem to indicate a small group of producers controlling a large portion of the output. As Rome expanded, establishing new cities and sending armies around the Mediterranean and beyond, infrastructural and military demand increased. This demand was met in part through contracts with professionals and in part through the social convention of donations of public works by prominent citizens. With the highest volume of demand in the hands of wealthy families and private

[620] The large litharge cargo of Agde G (**13**) is so poorly dated that I hesitate to include it as typical of lead trade of the period, but it is not impossible that large shipments of litharge did circulate in this period.

contractors, the likelihood of pre-arranged transactions is high. The Roman patronage system also likely fostered relationships between lead producers and consumers. Domestic use of lead was also high, perhaps supplied through the frequent shipments of moderately-sized consignments, destined for markets at major ports.

The Imperial period saw a shift away from the dominance of a few families in Carthago Nova. Production shifted west to individuals leasing mines in the Sierra Morena mountains and north to imperial and state holdings along the frontier. As infrastructural and military demand was supplied more by the emperor personally or by the state, the deliberate acquisition of lead sources was not just likely but necessary. The need for lead for the purification of silver at mints was also likely supplied from state holdings, although some municipal mints might have purchased lead on the open market depending on the frequency of their issues. Professional applications, such as art bronzes, pigments and maritime supplies, were abundant, but evidence for the large, pre-arranged transactions seen during the Republic is minimal beyond the reign of Augustus. Diverse cargoes of ingots with secondary merchant stamps suggest most non-imperial production was destined for open market sale. The late Roman cargo from Ploumanac'h (**63**) attests to continued primary metal shipments from Britain supplying demand from the continent; however, it is likely that recycling began to see a resurgence in less stable regions of the empire.

After separating out the 68 underwater lead sites by time period, one can, despite the relatively small sample size, see the benefit of comparing not just the ingots to each other, but the cargo types as well. By identifying the primary sectors of demand based on applications most common in each period, and comparing it to the goods found at wreck sites, one gains a better understanding of where a cargo was going and why. The focus on a small-scale, utilitarian cargo component, such as lead, helps illuminate the mechanisms of small-scale, often private, trade being conducted in the ancient world. Many other commodities were traded at this scale, but do not survive in the archaeological record, making lead an important proxy for more the perishable cargoes that supplied the daily needs of citizens throughout the Mediterranean world.

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APPENDIX A

CATALOG OF SHIPWRECKS CARRYING INGOTS, ORE OR LEAD MINERALS

Regions

Spain (ES)
1 - Andalucía
2 - Murcia
3 - Valencia
4 - Cataluña
5 - Balearic Islands

France (FR)
6- Côtes-d'Armor
7 - Pyrénées-Orientales
8 - Aude
9 - Hérault
10 - Gard
11 - Bouches-du-Rhône
12 - Var
13 - Haute Corse

Italy (IT)
14 - Straits of Bonifacio (FR/IT)
15 - Southern Sardinia
16 - Liguria
17 - Tuscany
18 - Lazio
19 - Campania
20 - Strait of Messina
21 - Apulia
22 - Emilia Romagna

Croatia (HR)
23 - Istria
24 - Dalmatia

Israel (IL)
25 - Haifa

Tunisia (TN)
26 - Tunis

Alegeria (DZ)
27 - Tipaza

Morocco (MA)
28 - Tangier-Tétouan (MA)

Great Britain (GB)
30 - Cheshire

Abbrevations used in entries:

d.	diameter
h.	height
l.	length
m.	mass
mlh.	maximum letter height
w.	width

Reference abbreviations:

BA	Talbert, R.A. 2000. *Barrington's Atlas of the Greek and Roman World*.
CIL	*Corpus Inscriptionum Latinarum*
DOM	Domergue, C. (unpublished) *Lingots de plomb romains estampillés fabriqués en Espagne*
LLGS	Laubenheimer-Leenhardt and Gallet de Santerre. 1973. *Recherches sur les lingots de cuivre et de plomb d'époque romaine dans les régions de Langeudoc-Roussillon et de Provence-Corse*.
RIB	Frere et al. 1990. *Roman Inscriptions in Britain*, Volume II, Fasc. 1: *Instrumentum Domesticum*.

List of Wrecks

Bronze Age

1) Kefar Shamir

Region: Haifa (IL) *BA* 69:A4
Date: 14th – 13th c. B.C.E.
Cultural Affiliation: Egypt
Number of Lead Ingots Found: 5
Discussion: Not a confirmed wreck site, these ingots were found in 1983-4 in conjunction with several small tin ingots and a group of stone anchors believed to date from the Late Bronze Age. They have been linked with Egypt due to their proximity to an Egyptian sickle-shaped sword and other Egyptian artifacts from the site. Due to the relatively small size of the ingots and their perforations, it may be that these lead objects represent a different form of artifact. Several stone fishing weights have been found from the Israeli coast that are similar in shape though slightly larger, but the shape is not associated with lead.

[620] Misch-Brandl suggests that a similar small, perforated tin ingot may have functioned as a pan-balance weight, and it is not impossible that similar pieces in lead may also have been used this way.
References: Raban and Galili 1985; Misch-Brandl 1985; Parker 1992a, 225.

1.1) Lead ingot
Type: C2
Metrics: l. ca. 11 cm, w. 7-8.5 cm; mass not given
Secondary Markings/Features: No markings are visible in photograph, although the text indicates there is one.
Notes: Rectangular in shape. Pentagonal piercing in top center. Measurements estimated from photographic scale.[621] Primarily rectangular in shape, with the bottom side slightly wider than the top.

1.2) Lead ingot
Type: C2
Metrics: l. ca. 11.5 cm, w. 6.5-7.5 cm; mass not given
Secondary Markings/Features:
a) Rough '+' symbol incised on convex side, bottom right quadrant.
Notes: Rectangular in shape. Square/pentagonal piercing in top center. Measurements estimated from photographic scale.[622] Appears to be primarily rectangular in shape with an irregular area on one side that may represent overflow from the mold.

1.3) Lead ingot
Type: C2
Metrics: l. ca. 10.5 cm, w. 4-8 cm, mass not given
Secondary Markings:
a) Rough  symbol incised on convex side, bottom right quadrant.
Notes: Rectangular in shape. Square/pentagonal piercing in top center. Measurements estimated from photographic scale.[623]

1.4) Lead ingot
Type: C2
Metrics: d. ca. 18-20 cm; mass not given
Secondary Markings/Features:
a) Rough '+' symbol incised on convex side, near center.
Notes: Round piercing in top center. Ovoid plano-convex shape. Measurements estimated from photographic scale.[624]

1.5) Lead ingot
Type: C2
Metrics: d. ca. 16 cm; mass not given
Secondary Markings/Features:
a) Rough  symbol incised on convex side, near right center.
Notes: Round piercing in top center. Ovoid plano-convex shape. Measurements estimated from photographic scale.[625]

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620 Galili et al. 2002, Fig. 3a.
621 Raban and Galili 1985, Fig. 9, upper left.
622 Raban and Galili 1985, Fig. 9, upper center.
623 Raban and Galili 1985, Fig. 9, upper right.
624 Raban and Galili 1985, Fig. 9, lower left.

2) ha-Ḥotrim

Region: Haifa (IL) *BA* 69:A4
Date: 12th-13th c. B.C.E.
Cultural Affiliation: Syrian?
Number of Lead Ingots Found: undisclosed number of fragments
Discussion: Not a confirmed wreck site, this group of associated artifacts found in 1980 on the sea floor consisted of fragments of lead and copper ingots, as well as other broken or used metal objects, such as horse bits and tools, prompting a comparison with the Cape Gelidonya wreck, which also carried an array of scrap metals.[626] As with the Kefar Shamir wreck, the published lead ingot is relatively small, and one must admit the possibility that it was not an ingot but perhaps a weight of some nature. Wachsmann and Raveh provide iconographic precedents for perforated lead ingots; [627] however, those cited from the tomb of Amenemopet are much larger than the one from this site. Since similar ingots depicted in the tomb of Rekhmire are associated with Syrian traders, the ingot fragment 2.1 is tentatively linked to this source.
References: Wachsmann and Raveh 1981;Wachsmann and Raveh 1984.

2.1 Lead ingot fragment M57[628]
Type: C1
Metrics: l. ca. 12 cm (max), w. ca. 7.5 cm (max), h. 2 cm; m. 0.8 kg
Notes: Hole in center is surrounded by a thickened rim on one side, which appears to be part of original casting. The ingot was cut in half in antiquity. Late Bronze Age tin ingots from the Uluburun shipwreck showed similar evidence of being cut into quarters.[629] This may have been a common method of producing small denominations for exchange with base metals.

Early Iron Age/Archaic

3) Dómu de S'Órku *BA* 48:A3

Region: Western Sardinia (IT)
Date: 700-400 B.C.E. (?)
Cultural Affiliation: Nuragic (?)
Number of Lead Ingots Found: 3+ (total not published)
Discussion: This site, first reported in 1982, consisted of a collection of metal ingots of three distinct shapes (described as *millstone, bun, and rectangular*, which I have interpreted as A2, A1 and A3 respectively). Lead ingots were present, in addition to ingots of a lead-tin alloy and also some of leaded bronze (lead-tin-copper contents not reported). All minerals are believed to have been derived from Sardinian sources. In addition, there were many lead plaques, some decorated with geometric designs. No hull was found, and no additional artifacts were reported from the site aside from a Nuragic jar handle used to date the site to the Iron Age.
References: Agus 1990, 448-9, and pl. 1; Parker 1992a, 164.

3.1) Lead ingot
Type: A2
Metrics: l. ca. 52 cm?, w. ca. 40 cm?[630]; m. not given
Notes: Chemical composition includes 64.50% Pb - 12.40% Sn - 2.04% Al – 0.81% Zn – 0.009% Ag. No marks or inscriptions reported.

4) Mazarrón 2 *BA* 27:D4

Region: Murcia (ES)
Date: ca. 650 B.C.E.

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[625] Raban and Galili 1985, Fig. 9, lower right.
[626] A piece of wood associated with this assemblage was radiocarbon dated to 1800 ±100 y.b.p. (Carmi 1987, 100). As the seabed in this region is subject to high energy disturbances, this wood may be instrusive.
[627] Wachsmann and Raveh 1984a, Fig. 5.
[628] Number in published photograph (Wachsmann and Raveh 1984, Fig. 4).
[629] Pulak 2000, 152-3.
[630] Dimensions tentatively estimated from photograph (Agus 1990, Pl. 1) based on interpretation of scale as 40 cm, which may not be accurate.

Cultural Affiliation: Phoenician
Number of Lead Ingots Found: 2800 kg of litharge
Discussion: This ship, excavated between 1995 and 1999, was loaded in the central section with thousands of fragments of plano-convex discs of litharge, totaling approximately 2800 kg.[631] Since it was found very close to shore, it is possible some of the cargo was salvaged in antiquity. Fragments of a single amphora, type Trayamar 1, were found near the mast step. A composite anchor of wood and lead was also associated with the wreck. Dating is based on the amphora combined with carbon dating of wood samples from the hull.
References: Negueruela 2004; Mederos Martín and Ruiz Cabrero 2004, 169.

5) Bajo de la Campana A

Region: Murcia (ES) *BA* 27:E4
Date: ca. 600 B.C.E.
Cultural Affiliation: Phoenician
Number of Lead Ingots Found: 1+ ton of lead ore
Discussion: Many surface finds were collected from this site by researchers, as well as sport divers, over the decades after its discovery in 1958. Archaeological surveying and mapping were conducted there in 1979 and 1988, but no excavation took place until 2008.[632] Situated at the base of a slope in close proximity to both a Punic and a Roman wreck, and disturbed and partially buried by modern salvage efforts in the area, intrusive artifacts are common and sometimes difficult to discern. The ship was carrying a cargo of raw materials from the western Mediterranean, including elephant tusks (some with Phoenician inscriptions) and a variety of metals, and possibly logs, pitch and minium.

Fusiform lead inots were reported from the early investigations, but no details on quantity, size or weight was ever published and later reports do not mention them. Recent excavation of the site has revealed tin and copper ingots of types A1 and A3, and two lead objects, which have not yet been published. One was a cone-shaped mass of lead weighing approximately 31 kg, which may have been intrusive from a later site. The other was a lead bar of rectangular section, 21 cm in length, and bent in the center similar to examples found on two later, Roman wrecks (**29**, **48**). Approximately 1 ton of small nodules of lead ore (galena) had been recovered as of the end of the 2010 field season, with future excavation planned. The ore appears to have been processed enough to remove waste rock (gangue) before shipping.
References: Más 1972, 71-2; Mas 1985; Mederos Martín and Ruiz Cabrero 2004; Polzer and Pinedo Reyes 2010; Polzer (pers. comm.).

6) Giglio Campese A

Region: Tuscany (IT) *BA* 41:D5
Date: ca. 580 B.C.E.
Cultural Affiliation: Greek?
Number of Lead Ingots Found: 9
Discussion: Carrying a mixed cargo, including Corinthian finewares, Etruscan amphorae and raw metals, the cultural origin of this wreck is still in dispute. The laced hull and painted fineware suggests a Greek origin, although it was originally believed to be Etruscan. The ship was also carrying small copper nuggets and iron bars, believed to have been used as currency. The site was discovered in 1961 but not excavated until 1983-5; looters destroyed the site before the excavation could be completed. As a result, the number of lead ingots found is likely significantly less than the original complement, as was the case for the copper ingots, of which only four plano-convex examples survive. To date, no lead isotope data has been published; such analysis could reveal whether the metals

[631] Early reports (Negueruela 2000, 183; Mederos Martín and Ruiz Cabrero 2004, 269-70) have described these as plano-convex lead ingots of 90% purity, but further analysis has shown them to be litharge.

[632] The first expedition was directed by J. Más García, the second by V. Antona del Val (Mederos Martín and Ruiz Cabrero 2004, 265). Full excavation of the site under J. Pinedo Reyes and M. Polzer is still in progress at the time of writing.

originated from Etruria, the Aegean, Spain or Sardinia.
References: Bound and Vallintine 1983; Bound 1991; Parker 1992a, 192.

6.1) 9 lead ingots
Type: A4
Metrics: l. 39.5-53 cm, w. 11.5-20 cm, h. 3.4-5.1 cm; m. 8.4-11.4 kg
Secondary Markings/Features:
a) . A V (freehand)
Notes: The ingots were irregularly shaped and followed no consistent weight standard. The example published in Bound is rougly rectangular in shape although one end narrows into more of a point.[633] The photograph shows three letters, the first not quite legible, the second appears to be an A, and the third, separated somewhat from the first two, is clearly a V.

7) Rochelongue
Region: Hérault (FR) *BA* 15:A3
Date: ca. 550 B.C.E.
Cultural Affiliation: Greek
Number of Lead Ingots Found: ore only
Discussion: Discovered in 1964, this site contained a heterogeneous metal cargo, perhaps the cargo of an itinerant smith or scrap merchant. 800 kg of copper ingots were found, along with two tin ingots, small sheets of tin and lead, lead ore (galena), and approximately 1700 assorted bronze objects. The dating is reasonably secure for a metal cargo, due to certain distinctive scrap items. No lead isotope data has been published on the galena. An origin in the Languedoc region has been suggested for the copper, but the various cargo elements were unlikely to have been acquired all in one place.
References: Parker 1992a, 369-70; Long 2004, 129.

8) Cala Sant Vincenç
Region: Balearic Islands (ES) *BA* 27:inset
Date: 520-500 B.C.E.
Cultural Affiliation: Greek
Number of Lead Ingots Found: 1 fragment
Discussion: This wreck, discovered in 2000, contained a cargo of amphoras (primarily wine and oil), finewares and tablewares, along with a few metal items, including a tin ingot (30.6 kg) and a cluster of tin strips or casting scraps (12.6 kg). The cargo components, originating variously from Greece, Italy, and Iberia, as well as the laced hull construction, suggest a strong connection to Massilia. No other lead items were reported beyond the partial ingot (**8.1**), which Nieto believes to be intrusive. Its form, however, is not inconsistent with other ingots of this time period.
References: Nieto et al. 2002; Nieto and Santos. 2008.

8.1) Fragment of lead ingot
Type: A1
Metrics: l. 8.2 cm, w. 5.7 - 6.4 cm; thickness 5.3; m. 1.86 kg
Secondary Markings/Features:
a) Several deep grooves on one surface may be a portion of an incised mark, or the remnants of an attempt to cut a piece from the ingot.
b) A small mark impressed on one side appears to have been made by a tool used to hold the piece steady while cutting it.
Notes: Chemical analysis confirms that it is an ancient metal, and the shape is consistent with other ingots of the period. Analysis by ED-XRF showed 99.6% Pb, 0.345% Sb and 0.018% Ag; NAA results include: 690 ppm Cu, 249 ppm Ag, 790 ppm Fe, 2720 ppm As, 5700 ppm Sb. Based on these results, it appears the lead had not been desilvered. The convex surface indicates it was cast in a rough mold, most likely a simple indentation in the ground. Lead isotope analysis indicates the ore originated in the Cartagena region.

Classical

9) Porticello
Region: Strait of Messina (IT) *BA* 46:C5
Date: 400-385 BC
Cultural Affiliation: Greek

[633] Bound 1991, Fig. 53

Number of Lead Ingots Found: ca. 24 (2 surviving)
Discussion: This wreck was heavily looted upon discovery in 1969. It was reported that approximately two dozen lead ingots were taken and sold for scrap; one was eventually recovered during police investigation, and one partial ingot was found in situ during later excavation. The ship was apparently carrying a heterogeneous cargo, which included amphorae from the northern Aegean and the western Mediterranean, ink pots, bronze sculptural pieces, which may have been scrap, and lead. Other lead objects found include 4 anchor stock cores, an anti-fouling ring, sheathing, 3 weights, and a very unusual collection of lead-silver discs and nuggets.[634] Based on lead isotope analysis, the ingots, discs and nuggets most likely originated from Laurion ores. While both surviving ingots are derived from the same region, they show marked differences in shape and technique, suggesting they came from different foundries. Comparative chemical analysis was not reported.
References: Eiseman and Ridgway 1987, 53-60; Parker 1992a, 332; on dating, see Lawall 1998.

9.1) Partial lead ingot Eiseman and Ridgway C34
Type: A5
Metrics: l. 27 cm, w. 9.5 cm, h. 6 cm; mass not given
Notes: Eiseman points out the shape is most similar to the ingots from Agde K which were cast in *Pinna nobilis* shells (**12.6-8**); the original surfaces are obscured by concretion, however, so no markings or impressions of shell structure can be discerned. The wider, rounded end shows evidence of having been cut off, so its original shape may have been somewhat different, but the overall tapering form has not been altered. Such tapering is most consistent with the A6 form.

9.2) Lead ingot Eiseman and Ridgway C35
Type: B1.3
Metrics: l. 51.9 cm, w. 12.5 cm, h. 6 cm; m. 25.7 kg[635]
Secondary Markings/Features:
a) *sigma, iota, eta* (in ligature in a shallow cartouche; stamped 6 times in a line on back at irregular intervals)
b) five short, straight, shallow incisions (between and below the two left-most impressions of (a))
Notes: Eiseman notes this ingot has a smooth back surface and flat base surface with minimal irregularities, suggesting a high level of technology and standardization. Based on its weight, the ingot may have been cast according the 6000 drachmas/talent Attic standard.[636] The letters are not believed to represent weights.

10) Ma'agan Mikhael
Region: Haifa (IL) *BA* 69:A4
Date: ca. 400 BCE
Cultural Affiliation: Greek
Number of Lead Ingots Found: 1
Discussion: Discovered in 1985 and excavated in 1988-89, this ship carried 12.5-13 tons of rock, believed to have been intended as building stone. Analysis of the

[634] These are listed in Eiseman and Ridgway (1987, 33-36) under two catalog entries (G20-G21), which differentiate between ingots and nuggets. The "cake ingots" (G20) range from 16-80 g, and do not appear to be true "ingots" with the idea of transporting raw metal for further processing, but rather more like a form of rough currency, like *hacksilber*. Samples from G20 and G21 show a predominantly lead composition (82.69% and 72-74% respectively), casting doubt on their use as currency and the authors suggest it may have been counterfeit bullion. However, there is no reason to suppose ancient merchants were unfamiliar with a silver-rich lead alloy and could not accurately assess its value.

[635] The notation in the final publication (Eiseman and Ridgway 1987, 54) that the ingot weighs "27.5 kg ± 50 kg" is presumed to be a typographical error.
[636] Eiseman and Ridgway (1987, 58) calculate the talent based on 1 drachma = 4.36 g, resulting in a talent of 26.16 kg.

stone points to at least two distinct lithic groups of different origins, possibly Cyrpus and Euboea. Analysis of wood from the hull suggests the ship was built in western or northewestern Asia Minor. The estimated date is based primarily upon pottery finds since ^{14}C dating results varied widely and were therefore inconclusive. Isotopic analysis of the lead ingot, several lead artifacts and galena residue from inside the hull were all consistent with Laurion ores. No other details on the lead ingot were published. According to Kahanov, it weighed 9.85 kg with a density of 10.99 and was heavily deteriorated. Based on the presence of the galena residue, the ship may have carried an Attic lead cargo prior to taking on the stone cargo. A wooden anchor with 2 lead cores (ca. 22 kg each) was found, but no lead sheathing was present.
References: Linder and Kahanov 2003, 144; 177; Linder and Kahanov 2004, 243-5; Kahanov 2009 (pers. comm.)

Hellenistic

11) Cala d'en Ferrer
Region: Balearic Islands (ES) BA 27:G2
Date: 3rd c. B.C.E.
Cultural Affiliation: Punic
Number of Lead Ingots Found: 4
Discussion: These ingots were found in 2008 off the north coast of Ibiza, with no associated hull or cargo. With so few ingots found, Hermanns suggests they perhaps came from a capsized vessel or were jettisoned in bad weather, for which the area is well known. All of the ingots were cast in sand molds with irregular shapes. Two bear impressed symbols from a northern Iberian syllabary. The symbols were described as being stamped while the metal was not yet cold, and were most likely still in the mold when marked. Chemical analysis of three of the ingots (**11.2-11.4**) suggest the lead had been desilvered and reconstituted from litharge. Lead isotope analysis supports an origin in the Sierra Morena. Inventory numbers from Museu Arqueologic d'Eivissa i Formentera (MAEF)
References: Hermanns, in press.

11.1) Lead ingot Hermanns 1
Type: A2
Metrics: max. l. 50.4 cm, max. w. 36 cm, max. h. 5.5 cm; m. 43 kg
Secondary Markings/Features:
a) *see Fig. A.1a* (freehand on base)
Notes: Ingot is in a private collection.

11.2) Lead ingot Hermanns 2
MAEF inv. 21.734-1
Type: A2/A4
Metrics: max. l. 37 cm, max. w. 34 cm, max. h. 6.5 cm; m. 30 kg
Secondary Markings/Features:
a) *see Fig. A.1b* (freehand on base)

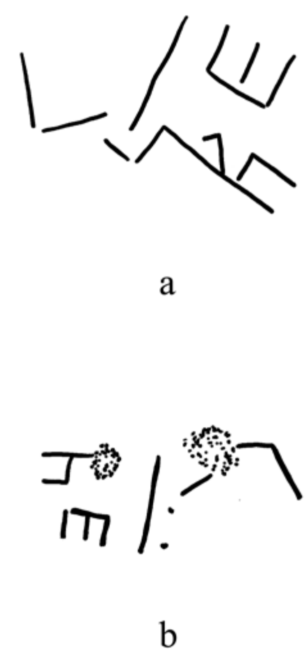

Fig. A.1. Punic inscriptions from the Cala d'en Ferrer wreck (**11**), with disconnected strokes indicative of punching. After Hermanns (in press).

11.3) Lead ingot Hermanns 3
MAEF 21.734-2
Type: A2/A4
Metrics: max. l. 35.5 cm, max. w. 29.5 cm, max. h. 6 cm; m. 12 kg
Secondary Markings/Features: none

11.4) Lead ingot Hermanns 4
MAEF 21.734-3
Type: A2
Metrics: max. l. 34 cm, max. w. 32 cm, max. h. 8 cm; m. 25 kg
Secondary Markings/Features: none

12) Agde K
Alternate names: Agde E; Îlot de Brescou
Region: Hérault (FR) *BA* 15:A/B3
Date: 3rd – 2nd c. B.C.E.
Cultural Affiliation: Greek?
Number of Lead Ingots Found: 8
Discussion: No hull is associated with these ingots, discovered in 1960. Several italic, Dressel 10 and 45 amphorae fragments were found nearby but may not be associated with the ingots, as there were likely at least two wrecks in the area originally published as "gisement E." Due to the use of *Pinna nobilis* shells as a mold for some of the ingots, Bouscaras suggests the mine from which they originated must have been near a coastal area where this species thrived, such as Capraria or Cartagena. Recent isotopic testing of several of the ingots has confirmed this, showing signatures consistent with the Sierra de Cartagena.[637] Inventory numbers are from Musée du Vieux Biterrois, Béziers (MVB).
References: Bouscaras 1959-61; Bouscaras 1964, 269; LLGS 146-161, 169-72; Parker 1992a, 44, 46.

12.1) Lead ingot LLGS 26; MVB inv. AS 53
Type: A4
Metrics: (approximated based on photograph) max. l. 47 cm, max. w. 16 cm; (published range for group) 5-7 cm; 40 kg
Secondary Markings/Features:
a) Π (*right arm truncated)* (punched or stamped in center of flat face, mlh. 2 cm)
b) *vertical line* [incised, several centimeters to the right of (a]
Notes: The symbol (a) appears to be a letter, but its form has many potential interpretations. Possibilities include the archaic form of the Greek letter *pi*, although the form persists in various locations until the first century B.C.E.; an archaic form of the Roman *P* common from the mid-third to mid-second century B.C.E. but persisting through the end of the Republic; or even an Iberian letter or numbering system similar to some found on amphorae. The line (b) appears deliberate rather than accidental, and may have acted as some sort of control mark. Qualitative chemical analysis shows the presence of silver and trace levels of bismuth, with no tin, arsenic, antimony, or gold.[638]

12.2) Lead ingot LLGS 27; MVB inv. AS 53
Type: A4
Metrics: (approximated based on photograph) max. l. 54 cm, max. w. 17 cm; (published range for group) 5-7 cm; m. 33 kg
Secondary Markings/Features:
a) Π (*right arm truncated)* (punched or stamped near center of flat face, mlh. 2 cm; possible duplicate mark on convex face)
Notes: Inscription (a) has noticeably thicker lines (ca. 0.3 cm) that in 12.1, and appears to have been made with an instrument in one strike. The possible second occurrence of (a) is too concreted to identify positively. Qualitative chemical analysis shows the presence of silver and trace levels of bismuth.

12.3) Lead ingot LLGS 28; MVB inv. AS 53
Type: A2
Metrics: (approximated based on photograph) max. l. 55 cm, max. w. 20 cm; (published range for group) 5-7 cm; 45 kg
Secondary Markings/Features:
a) Π (*right arm truncated)* (freehand near edge of flat face toward center, mlh. 1.4 cm)

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[637] Trincherini et al. 2009, Table 2.

[638] A full list of elements tested for and not found is: Sn, As, Sb, Ni, Au, Zn, Co, Fe (LLGS 147).

b) *vertical line* (punched(?) two times, at different angles, near edge at one end of flat face)
Notes: Inscription (a) interpreted as in 12.1. The vertical lines (b) may or may not be significant; they appear in to have been struck using a tool such as a chisel and their placement appears random. Qualitative chemical analysis shows presence of silver, and trace levels of bismuth and tin.

12.4) Lead ingot LLGS 29; MVB inv. AS 53
Type: A3
Metrics: (approximated based on photograph) max. l. 65-70 cm, max. w. 18 cm; (published range for group) 5-7 cm; 55 kg
Secondary Markings/Features:
a) Π (*right arm truncated)* (freehand near one end of flat face along edge, mlh. 3.5 cm)
b) *vertical line* (punched just below right arm of (a))
Notes: This ingot is very elongated with relatively sharp points at either end, often described as fusiform (spindle-shaped). Inscription (a) interpreted as in 12.1, and appears to have been formed by a series of small dashes with many taps of a small instrument. Qualitative chemical analysis shows presence of silver, and trace levels of antimony, with no bismuth.

12.5) Lead ingot LLGS 30; MVB inv. AS 53
Type: A2
Metrics: (approximated based on photograph) max. l. 40 cm, max. w. 23 cm; (published range for group) 5-7 cm; 33 kg
Secondary Markings/Features:
a) Π (*right arm truncated)* (stamped once near edge of flat face, and once on convex face, mlh. 3.5 cm)
b) *vertical line* (punched(?) twice near opposite end of flat face from (a))
Notes: Inscription (a) interpreted as in12.1; the one on the flat face has noticeably thicker lines (ca. 0.3 cm) similar to12.2, and probably also was made with a single strike. Qualitative chemical analysis shows presence of silver and bismuth, and trace levels of antimony.

12.6) Lead ingot LLGS 31; MVB inv. AS 53
Type: A6
Metrics: (approximated based on photograph) max. l. 48 cm, max. w. 18 cm; (published range for group) 5-7 cm; 51 kg
Secondary Markings/Features:
a) Π [*right arm truncated)* (freehand(?) near edge of flat face, mlh. 2 cm]
Notes: Inscription (a) has more irregular lines than those of the other ingots, although it may have been distorted by the heavily concreted surface; the meaning is interpreted as in 12.1. Cross section shows a much sharper, almost triangular shape, with one end much narrower than the other; it appears to have been cast using a *Pinna nobilis* shell as a mold. Qualitative chemical analysis shows presence of silver, and trace levels of antimony and bismuth.

12.7) Lead ingot LLGS 32; MVB inv. AS 53
Type: A6
Metrics: (approximated based on photograph) max. l. 65-70 cm, max. w. 22 cm; (published range for group) 5-7 cm; 66 kg
Secondary Markings/Features:
a) Π (*right arm truncated)* (punched or stamped twice on flat face toward wider end, oriented almost perpendicular to each other; one mlh. 3 cm, the other larger, thinner and fainter)
b) *vertical line* [punched four times on flat face, three roughly parallel and at the wider end, one near the larger of (a) near center]
Notes: Inscription (a) interpreted as in 12.1. One end is much narrower than the other, and traces of veins on the convex side provide further evidence for a *Pinna nobilis* shell mold. Qualitative chemical analysis shows presence of silver, and trace levels of antimony, arsenic, bismuth, and iron.

12.8) Lead ingot LLGS 33; MVB inv. AS 53
Type: A6
Metrics: (approximated based on photograph) max. l. 43 cm, max. w. 15

cm; (published range for group) 5-7 cm; 15 kg
Secondary Markings/Features: none detectable
Notes: This ingot is heavily deteriorated with little or no original surface remaining, although its overall shape suggests it may also have been cast in a *Pinna nobilis* shell. Its original weight was also probably closer to the other ingots in this group. Qualitative chemical analysis shows presence of silver and bismuth with no trace elements found.

13) Agde G

Region: Hérault (FR) *BA* 15:B3
Date: 5th – 2nd c. B.C.E.?
Cultural Affiliation: unknown
Number of Lead Ingots Found: litharge only
Discussion: This cargo of litharge, estimated at 100 tons in "tablet" form, was reported in 1961. The tablets were stacked and covered a 20 x 14 m area. No other datable material was found, but the site is believed to be linked to pre-Roman Greek activity in the region. The sheer size of this cargo, however, is so far unprecedented in pre-Roman wrecks, suggesting perhaps a later date is more likely.
References: Parker 1992a, 45.

14) Cabrera B

Alternate names: Cabrera 2, Nave Cartaginesa de Cabrera[639]
Region: Balearic Islands *BA* 27:inset
Date: ca. 250-225 BC
Cultural Affiliation: Punic
Number of Lead Ingots Found: 4
Discussion: This wreck was not excavated, but items recovered from looters between 1965 and 1970 have been published. The primary cargo appears to have been agricultural products in amphorae from a range of origins, including North Africa, Ampurias, Ibiza and possibly Malta. Some black gloss pottery on board may date to the first half of the third century, though Guerrero Ayuso believes the ship sank during the Second Punic War based on the similarity of the overall amphora assemblage to that of the destruction levels from the end of the war, particularly Carthago Nova, conquered by Scipio in 209 B.C.E.

The island of Cabrera, ancient Capraria, was notorious for its treacherous coastline and the many shipwrecks there,[640] three of which are included here (see also **40** and **41**). Due to the heavy looting of the site, only four lead ingots are known. Without knowing whether more had been present, it is difficult to determine if the lead was part of the cargo or ship's stores. If the ship was traveling during wartime, the lead may even have been a military consignment or supplies for making bullets for defense of the ship. Isotopic testing has linked these ingots to the Sierra de Cartagena region.[641]
References: Veny and Cerda 1972, 322; Cerda 1978, 89, figs. 35 and 37; Guerrero Ayuso 1990, 112-3; Parker 1992a, 80-1.

14.1) 4 Lead ingots

Type: A6
Metrics: l. 65 cm, w. 26 cm, h. 5 cm; m. 38.6-40 kg (based on two ingots)
Notes: Dimensions based on the 40 kg ingot from Museo del Lluc (Majorca).

Roman Republic

15) Algajola

Region: Western Corsica (FR) *BA* 48:C2
Date: 150 – 75 B.C.E. (?)
Cultural Affiliation: Roman
Number of Lead Ingots Found: 44
Discussion: First reported in 1973, these ingots were found scattered over a 200-meter area,[642] in association with six lead anchor stocks, two Dressel 1A amphora necks and fragments of ceramic tiles, but no hull was found. Dating is based primarily

[639] See Bost et al. 1992, 13-16 for full disambiguation of the Cabrera wrecks.

[640] Plin. *HN* 3.11.
[641] Trincherini et al. 2009, Table 2.
[642] The text does not specify that this was 200 square meters, but 200 linear meters is an unusually long spread for a wreck site.

on the amphora evidence. There are no inscriptions on the ingots, although the remains of two cartouches are visible on the back of several examples,[643] mostly likely type D1b. No metric data was published. Several ingots were tested isotopically and were consistent with lead from the Sierra de Cartagena region.
References: Liou 1973, 606; Parker 1992a, 52; Trincherini et al. 2009, table 2.

16) Agde J

Alternate Name(s): Agde-Marseillan(?)
Region: Hérault (FR) *BA* 15:B3
Date: 90-70 B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 6
Discussion: These ingots were discovered as part of a heavily looted site, which apparently held the remains of a mixed cargo. Other finds included a millstone, a lead anchor stock, amphorae of a variety of origins, including Massiliote, and a single copper ingot. The finds were dated by comparison to the Mahdia wreck (**20**) which carried two ingots similar to 16.2. Lead isotope testing supports an origin in the Sierra de Cartagena region, already suggested by the names attested in several of the mold makrs.[644] Inventory numbers cited are from the Musée d'Agde (MA).
References: Fonquerle 1982, 128-30; *LLGS* 130-145, and 179-189 (for discussion of the inscriptions); Parker 1992a, 14.

16.1 Lead ingot LLGS 20; MA inv. 230
Type: D1b
Metrics: l. 47.5 cm, w. 10 cm, h. 9 cm; m. 33.9 kg[645]
Mold Mark(s):
a) Ṣ………IMP̣ (cartouche l. 16 cm, w. 3 cm)
b) R…TI (cartouche l. 6.7 cm, w. 3 cm)
Secondary Markings/Features:
c) M·V (stamped on side)
d) M·V·S (stamped on same side as (c).)
Notes: This ingot was an outlier, found a distance from rest of the group and may not be associated with them, as there were multiple wrecks in this area. It is the only ingot of the group that has secondary stamps. Cartouches show an unusual asymmetrical arrangement, with a large central cartouche and smaller one to the right; although there is space for one to the left of the central cartouche, the area is untouched. Not enough of the inscriptions are left to reconstruct any names, but the final two letters of (a) are interpreted as *M(arci) f(ilii)*. Qualitative chemical analysis revealed the presence of Cu, Ag, and trace levels of Fe.

16.2 Lead ingot LLGS 21; MA inv. 442
Type: D1b
Metrics: l. 48.5 cm, w. 9.3 cm, h. 9.2 cm; m. 33.2 kg
Mold Mark(s):
a) L·PLANI·L·F·RVSSINI (cartouche l. 14.2 cm, w. 2.2 cm)
b) *anchor* (pointing right; cartouche l. 6.7 cm, w. 3 cm)
Notes: Cartouches are asymmetrical in size, but are centered as a unit on the back. Inscription (a) is interpreted as *L(ucii) Plani(i) L(ucii) f(ilii) Russini*. The Planius family is widely attested, in the Roman world with ties to Latium and Campania.[646] It is well attested in Carthago Nova in the first century B.C.E. and ingots with a Planius inscription, referencing either Marcus or Lucius, have been found in Italy, Sicily, southern France, and many underwater sites (see **17**, **20**, **21**, **25**, **28**, **30**, and **31**).[647] Marcus

[643] Based on Trincherini et al. (2009, Table 2).
[644] Trincherini et al. 2009, Table 1.
[645] All measurements were taken from LLGS except masses, which were republished with more precision in Fonquerle (1982, 128).
[646] Domergue 1965, 21. Domergue also notes that in 45 B.C.E Cicero (*Ad Fam.* 9.13.2) wrote to his son-in-law Dolabella, a representative of Caesar in Spain, to intercede on behalf of a *Marcus Planius Heres*. There is no evidence that he was connected to Russinus, it is possible the families had business ties.
[647] Trincherini et al. (2009, 144) also report a Planius ingot among several from an underwater site near Gavdos Island, south of Crete.

and Lucius are both identified as *Marci filius*, thus are likely to have been brothers or father and son. Planius mold marks are frequently accompanied by either an anchor or a dolphin, but no consistent pattern is evident. Qualitative chemical analysis of the ingot revealed the presence of Cu, Ag, and Bi.

16.3 Lead ingot LLGS 22; MA inv. 684[648]
Type: D1c
Metrics: l. 44 cm, w. 10.3 cm, h. 9.7 cm; m. 32.35 kg
Mold Mark(s):
a) SOC (cartouche l. 4.5 cm, w. 2.2 cm)
b) ḶGARGILITFẸTMḶAEṬỊḶIML (final ML in ligature; cartouche, l. 20.3 cm, w. 3 cm; mlh 16 mm)
c) *dolphin* (facing left; cartouche l. 4 cm, w. 2.3 cm)
Notes: Inscription (a) interpreted as *Soc(ietas)* or *Soc(ietatis);* and (b) as *L(ucii) Gargili(i) T(iti) f(ilii) et M(arci) Laetili(i) M(arci) l(iberti)*. The inscription is a relatively rare record of a business association between a Roman citizen and a freedman. Gargilius is a widely attested name, with most examples coming from Rome, southern Italy and Sardinia, where it may have originated, as well as Africa. In Spain, the family is primarily attested in the area of Tarragona, ancient Tarraco, in Catalonia, but is not well known in Carthago Nova. The Laetilius family, on the other hand, is well attested in Cartagena, with one member having been a *duumvir* and appearing on local coinage. Several other freedman of the Laetilius family have been attested in inscriptions from Carthago Nova.[649]

Qualitative chemical analysis revealed the presence of Cu, Au, Bi and trace levels of Sn.

16.4 Lead Ingot LLGS 23; MA inv. 443
Type: D1a
Size: l. 46 cm, w. 9.1 cm, h. 9.1 cm; m. 32.5 kg
Mold Mark(s):
a) SOC·MC·PONTILIENORVM M·F (cartouche l. 16.2 cm, w. 2.5 cm; NT in ligature; two dots over C in MC)
Notes: Inscription (a) is interpreted as *Soc(ietatis) M(arci) (et) G(aii) Pontilienorum M(arci) f(iliorum)*. The Pontilienus family has been attested on ingots at Cartagena and Agde, as well as one from Volubilis inscribed with only Gaius's name.[650] The latter ingot also includes the syllable *FAB*, which may attest a link to the tribe *Fabia* or may simply be an abbreviated *cognomen*. Two funerary inscriptions attest to the family's presence in Carthago Nova.[651] Marcus and Gaius are presumed to have been brothers, but little else is known of this family. Over 700 ingtos from these producers were found in the Mal di Ventre wreck (**21**). Qualitative chemical analysis revealed the presence of Cu, Ag, and trace levels of Ni.

16.5 Lead Ingot LLGS 24; MA inv. 682
Type: D1a
Metrics: l. 46 cm, w. 9.4 cm, h. 9.4 cm; m. 32.45 kg
Mold Mark(s):
a) SOC·MC·PONTILIENORVM M·F (cartouche l. 16.1 cm, w. 2.5 cm; NT in ligature)
Notes: Inscription (a) interpreted as in 16.4. Qualitative chemical analysis revealed the presence of Cu, Ag, Bi, and trace levels of Ni and Fe.

16.6 Lead Ingot LLGS 25; MA inv. 683

Sufficient information on this wreck was not available in time for inclusion in this catalog. This is the furthest east any ingot from Roman Spain has been discovered.
[648] This ingot has been identified by Domergue variously as 1041 (1990, 325) and 1023 (Trincherini et al. 2009, Table 4).
[649] Domergue 1990, 324 (Table 14). Lead ingots attesting freedmen of other families include 21.8, 22.3-4, 25.1 and 25.2.

[650] *LLGS* 182.
[651] *CIL* 01, 03349g, and *Hispania Epigraphica* 5, 1995, 585, which refers to a *liberta* of the Pontilienus family.

Type: D1a
Metrics: l. 46 cm, w. 9.3 cm, h 9.4 cm; m. 32.4 kg
Mold Mark(s):
a) SOC·MC·PONTILIE…. (cartouche l. 16.5, w. 2.5 cm; NT in ligature)
Notes: Inscription (a) interpreted as in 16.4. Molten lead flowed into rest of the cartouche, obscuring the remainder of stamp; a straight vertical mark was impressed between M and C, presumably from an accidental post-casting event. Qualitative chemical analysis revealed the presence of Cu, Ag, Bi, Fe, and trace levels of Ni.

16.7) 10 Lead ingots
Type: D1
Metrics: (based on best preserved example) l. 45.5 cm, w. 9.5 cm, h. 8.5 cm; back, l. 43.5 cm; m. 26.25 kg
Mold Mark(s): none
Secondary Markings/Features: none reported
Notes: Several examples were extremely degraded by underwater corrosion.

17) Escombreras 2
Alternate Names: Escombreras III[652]
Region: Murcia (ES) *BA* 27:E4
Date: early 1st c. BC
Cultural Affiliation: Roman
Number of Lead Ingots Found: 4
Discussion: From excavations conducted in the bay of Cartagena between 1997 and 2002 came a heterogeneous cargo of primarily Italian origin, including Dressel 1a amphorae, some with traces of pozzolana, Lamboglia 2 wine amphorae, and two Apani V, which probably carried oil, as well as black glazed ware and a consignment of lamps. The ingots are presumed to have been cargo, but based on their limited number, they might also have been part of the ship's stores.[653] Two of the three inscriptions found were also represented in the Cartagena B wreck (**30**). Lead isotope testing supports the region around Cartagena as the origin of the lead.[654] Inventory numbers from the Museo Arqueológico de Alicante (MARQ).
References: Pinedo Reyes and Alonso Campoy 2005, 28-30, 62, 94 (R&C).

17.1) Lead ingot R&C cat. 63; MARQ inv. ESC/1/09/88/3/4467
Type: D1c
Metrics: l. 45.3 cm, w. 9.3 cm, h. 9.3 cm; m. approx. 33 kg
Mold Mark(s):
a) *dolphin*
b) C·AQVINI·M·F
c) *anchor*
Notes: No secondary marks were reported. Inscription (a) is interpreted as *C(aii) Aquini(i) M(arci) f(ilii)*. The same three mold marks appear on ingots from Cartagena B (cat. 30), while the name Marcus Aquinus was attested on ingots from Bajo de Dentro (**27**). The *gens* Aquinia is widely attested in the Roman world, appearing in Carthago Nova as early as the late second century B.C.E.[655] The family was still prominent there by late first century B.C.E., as evidenced by local coinage bearing the name of *Caius Aquinius Mela, duumvir quinquennalis* in the year 22/21 B.C.E.[656] A Marcus Aquinius was mentioned in *Bellum Africum* as a supporter of Pomey pardoned by Caesar.[657]

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[652] Povedo Navarro (2000, 299-303) uses this wreck designation, thus the entry in *Hispania Epigrafica 10*, 2000, 383 also cites it this way, but the excavators labeled it Escombreras 2.

[653] A great deal of underwater activity has been conducted in the area starting in the mid-20th century (Pinedo Reyes and Alonso Campoy 2005, 15-17), so it is difficult to determine if any significant materials were removed from the site before excavation commenced.
[654] Trincherini et al. 2009, Table 1.
[655] Poveda Navarro 2000, 305.
[656] Poveda Navarro 2000, 306. Domergue (1966, 45) prefers the interpretation *Aquinus* to *Aquinius*, but I have chosen to follow the more recent scholarship in this case.
[657] *B Afr.*57 and 89.

17.2) Lead ingot R&C cat. 146b; MARQ inv. ESC/I/18/61/2/10355
Type: D1c
Metrics: l. 45.3 cm, w. 9.3 cm, h. 9.4 cm; m. approx. 33 kg
Mold Mark(s):
a) *dolphin*
b) C·AQVINI·M·F
c) *anchor*
Notes: No secondary marks were reported. Inscription (a) is interpreted as in 17.1

17.3) Lead ingot R&C cat. 146a; MARQ inv. ESC/I/18/81/2/10356
Type: D1c
Metrics: l. 45.3 cm, w. 9.4 cm, h. 9.1 cm; m. approx. 33 kg
Mold Mark(s):
a) L·PLANI·L·F
b) *dolphin* (facing left)
c) RVSSINI
Notes: No secondary marks were reported. Inscription (a) and (c) are interpreted together as *L(uci) Plani L(uci) f(ilii) Russini*. See **16.2** for details on the Planius family.

17.4) Lead ingot R&C cat. 146c; MARQ inv. ESC/I/29/36/2/4466
Type: D1c
Metrics: l. 46.7 cm, w. 9.6 cm, h. 8.7 cm; m. approx. 33 kg
Mold Mark(s):
a) *dolphin*
b) SOC·BALIAR
c) *anchor*
Notes: No secondary marks were reported. This inscription has not been attested elsewhere. Reyes and Campoy suggest it was produced by a *societas* based in the Balearic Islands, where much lead activity has been attested archaeologically. Commerical ties between Carthago Nova and the islands were well in place in the first century B.C.E. and likely date to the Punic period or earlier.

18) Punta dell'Arco
Alternate names: Isole de Ventotene (several other wrecks have also been published under this designation)
Region: Campania (IT) BA 44:D4
Date: early 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 14
Discussion: This wreck was first published in 1985 and only in brief with minimal details provided. No primary cargo was identified, although wine amphorae (Dressel 1B) were found, on which dating is based. The location of the wreck, south of Rome and approaching Naples, suggests the ship was bound for Campania; however, since Dressel 1B amphorae were most commonly produced in central Italy, the ship may actually have been leaving port. The name attested on the ingots also indicates connections with Campania. The island of Ventotene, ancient Pandataria, is approximately 50 km off the Italian coast from the port city of Puteoli.[658] A recently-discovered set of 5 deep-water wrecks from the Roman period attest to the frequency of traffic (and disasters) in this area.[659]
References: Gandolfi 1985b, 678-9; Parker 1992a, 351.

18.1) Lead ingot
Type: D1c
Metrics: none given
Mold mark(s):
a) *dolphin*
b) C·VTIVS C·F
c) *caduceus*
Secondary Markings/Features: none reported
Notes: Inscription (b) interpreted as *G(aii) Utius G(aii) f(ilii)*. Ingots from the Capo Testa B wreck (**22.1-2**) link this *gens* to the tribe Menenia of Latium and Campania. This family name is well attested on lead ingots (cf. **21.5**, **22.1-2**, **23.3**, **26.1**, and **27.13**) but is otherwise relatively rare.

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[658] An artificial harbor constructed by Augustus offered shelter for ships in bad weather, although this was not in place before the late 1st century B.C.E. (Hartel 2010).
[659] Site 4 of this collection, dated to the first century C.E., contains "metal bars" but the metal has not yet been identified (Aurora Trust 2009).

19) El Hornillo

Alternate Names: Aguilas; El Nido del Cuervo

Region: Murcia (ES) *BA* 27:D4

Date: 80-50 B.C.E.

Cultural Affiliation: Roman

Number of Lead Ingots Found: 15

Discussion: The ingots were recovered from a partially looted site near Aguilas, Spain in 1977. The primary cargo appears to have been wine, based on the predominance of Dressel 1C amphorae from the site. As this type of amphora was primarily produced in Campania and the wreck was found west of Cartagena, it is possible the ship was traveling westward and picked up the ingots on the way past Cartagena. Fifteen ingots is generally considered too many for ship stores, so this is likely the remains of a small consignment, perhaps for a port such as Cadiz or even for a silver mine with limited lead ore.

No other metals are associated with the site. The ingots were published as a group, with only ranges of weights and sizes given. Thirteen bore the same inscription (**19.1a**); the inscriptions on the two remining ingots, a D1a and a D1c, were not reported.

References: Domergue and Mas 1983, Parker 1992a, 213.

19.1) 13 Lead ingots

Type: D1a

Metrics: average/range: l. 45 cm, w. 10-11 cm, h. 9-10 cm; back l. 40 cm; m: 24-36 kg.

Mold Mark(s):

a) Q SEI·P·F·MEN POSTVMI (cartouche l. 22.6 cm, w. 2.2 cm; mlh: 1.3 cm)

Secondary Markings/Features:

b) AI (stamped on rear face; mlh 1.9 cm)

Notes: Inscription (a) interpreted as *Q(uinti) Sei(i) Publi(i) f(ilii) Men(enia tribu) Postumi*. No interpretation was suggested for (b). The Menenia tribe occupied territory in northern Campania and southern Latium. They were enfranchised at the end of the social wars in 89 B.C.E., thus this date is often used as a terminus post quem for dating ingots with MEN in the inscription. Domergue has identified at least 7 families attested on lead ingots with ties to this region.[660]

Domergue and Mas identified the *gens* Seia as a prominent commercial family of central Italy in the first century B.C.E. A Quintus Seius Postumus was mentioned by Cicero as having been murdered in Rome by P. Clodius Pulcher in 58/57 BC, [661] but whether this is the same person named on the ingot or even a relative we will likely never know.

20) Mahdia

Region: Mahdia (TN) BA 33:H1

Date: 80-70 B.C.E.

Cultural Affiliation: Roman?

Number of Lead Ingots Found: 12

Discussion: This remarkable wreck, discovered in 1907, carried a cargo of second-century B.C.E. bronze statuary and stone architectural pieces thought to have been plundered from mainland Greece. The sinking date has been established primarily through the pottery on board.

In addition to the 12 ingots found at the site, other lead items include five anchor stocks, several lengths of pipe, fragments of lead sheathing, two sounding weights, an antifouling ring, numerous small cone-shaped and pyramidal pieces believed to be fishing weights, and four lead seals. Given the nature of the cargo and the quantity of lead shipboard items, it is believed the ingots were part of the ship's stores. Isotopic analysis links the ingots, sheathing, anchors and pipes all to Cartagena.[662] ID

[660] Domergue 1990, Table 10 (254-6). The families are Atellius, Carulius, Messius, Nona, Planius, Seius, and Utius.

[661] Cicero (*Dom* 115) states that Clodius coveted the man's house and when he refused to sell it, Clodius poisoned him in order to acquire it at auction. He mentions the event twice more (*Dom*. 129, *Har. resp.* 14.30), calling Seius a Roman knight and *vir optimus*.

[662] The association of the ingots with a Greek cargo at first led to the conclusion that the lead originated from Laurion (see Domergue 1965, 9-10). Interestingly, the lead from the socket in the statue of Hermes was consistent with

numbers are from the Rheinisches Landesmuseum Bonn (RLM).
References: Parker 1992a, 252; Eck 1994; Salies 1994; Gelsdorf 1994; Päffgen and Zanier 1994; Schmitz 1994; Begemann and Scmitt-Strecker 1994.

20.1) Lead ingot RLM inv. MB 52.1
Type: D1c
Metrics: l. 44.5 cm, w. 9.4 cm, h. 8.5 cm; m. 30.714 kg
Mold Mark(s):
a) […] (cartouche l. 7.0 cm, w. 1.5 cm)
b) […] (cartouche l. 5.1 cm, w. 1.7 cm)
c) […] (cartouche l. 7.1 cm, w. 1.7 cm)
Notes: All cartouches are too deteriorated to discern the inscriptions. No secondary marks reported.

20.2) Lead ingot RLM inv. MB 52.2
Type: D1c
Metrics: l. 44.5 cm, w. 10.3 cm, h. 10 cm; m. 32.846 kg
Mold Mark(s):
a) M PḶANI L·F (cartouche l. 7.0 cm, w. 1.4 cm)
b) *dolphin* (cartouche l. 5.0 cm, w. 1.3 cm)
c) RVSSINI (SS reversed; cartouche l. 7.4 cm, w. 1.4 cm)
Notes: No secondary marks reported. Inscriptions (a) and (c) interpreted together as *M(arci) Plani(i) L(ucii) f(ilii) Russini*. See **16.2** for details on the Planius family. As ingots from both Lucius and Marcus were found on this wreck, and are thus roughly coeval, and both are sons of Lucius, it is possible that the two individuals were brothers.

20.3) Lead ingot RLM inv. MB 52.3
Type: D1a
Metrics: l. 44.0 cm, w. 9.8 cm, h. 10 cm; m. 31.759 kg
Mold Mark(s):
a) CN·ATELL[I·T·]F·MENE (NE in ligature; cartouche l. 22.5 cm, w. 1.8-2.0 cm)
Notes: No secondary marks reported. Inscription (a) interpreted as *Cn(aei) Atelli(i) T(iti) f(ilii) Mene(nia tribu).* Members of the *gens* Atellia at Carthago Nova were prominent citizens in the late first century C.E., likely with close ties back to family members in Herculaneum.[663] See also 21.6, 22.3-4 and 25.2.

20.4) Lead ingot RLM inv. MB 52.4
Type: D1a
Metrics: l. 44.5 cm, w. 9.6 cm, h. 10.2 cm; m. 31.806 kg
Mold Mark(s):
a) CN·ATELLI·T·F·MENE (NE in ligature; cartouche l. 22.6 cm, w. 1.8-2.0 cm)
Notes: No secondary marks reported. Inscription (a) interpreted as in 20.3.

20.5) Lead ingot RLM inv. MB 52.5
Type: D1c
Metrics: l. 44.0 cm, w. 9.4 cm, h. 8.0 cm; m. 31.498 kg
Mold Mark(s):
a) M PLANI L·F (cartouche l. 7.4 cm, w. 1.4 cm)
b) *dolphin* (facing left; cartouche l. 4.9 cm, w. 1.4 cm)
c) RVSSINI (SS reversed; cartouche l. 7.0 cm, w. 1.4 cm)
Notes: No secondary marks reported. Inscriptions (a) and (c) interpreted as in 20.2.

20.6) Lead ingot RLM inv. MB 52.6
Type: D1c
Metrics: l. 44.5 cm, w. 9.7 cm, h. 10.0 cm; m. 32.124 kg
Mold Mark(s):
a) M PLANI L·F (cartouche l. 7.1 cm, w. 1.6 cm)
b) *dolphin* (facing left; cartouche l. 5.0 cm, w. 1.6 cm)
c) RVSSINI (SS reversed; cartouche l. 7.0 cm, w. 1.5 cm)

Laurion, and that of “Agon” with Sardinia (Begemann and Schmitt-Strecker 1994, 1074-5).

[663] Barreda Pascual 1998, 167.

Notes: No secondary marks reported. Inscriptions (a) and (c) interpreted as in 20.2.

20.7) Lead ingot RLM inv. MB 52.7
Type: D1c
Metrics: l. 42.5 cm, w. 9.9 cm, h. 10.2 cm; m. 33.09 kg
Mold Mark(s):
a) M PLANI L·F (cartouche l. 6.6 cm, w. 1.5 cm)
b) *dolphin* (facing left; cartouche l. 5.0 cm, w. 1.3 cm)
c) RVSSINI (SS reversed; cartouche l. 7.2 cm, w. 1.5 cm)
Notes: No secondary marks reported. Inscriptions (a) and (c) interpreted as in 20.2.

20.8) Lead ingot RLM inv. MB 52.8
Type: D1c
Metrics: l. 47.5 cm, w. 9.8 cm, h. 9.2 cm; m. 33.842 kg
Mold Mark(s):
a) M PLANI L·F (cartouche l. 7.0 cm, w. 1.5 cm)
b) *anchor* (facing left; cartouche l. 5.0 cm, w. 1.3 cm)
c) RVSSINI (SS normal; cartouche l. 6.3 cm, w. 1.4 cm)
Notes: No secondary marks reported. Inscriptions (a) and (c) interpreted as in 20.2.

20.9) Lead ingot RLM inv. MB 52.9
Type: D1b
Metrics: l. 44.5 cm, w. 10.3 cm, h. 10.8 cm; m. 33.842 kg
Mold Mark(s):
a) L·PLANI Ḷ[F] RVSSINI (cartouche l. 13.1 cm, w. 1.6 cm)
b) *anchor* (facing left; cartouche l. 6.0 cm, w. 1.5 cm)
Notes: No secondary marks reported. Inscription (a) interpreted as *L(ucii) Plani(i) L(ucii) f(ilii) Russini*, already attested on **16.2**.

20.10) Lead ingot RLM inv. MB 52.10
Type: D1b
Metrics: l. 48.0 cm, w. 9.4 cm, h. 9.0 cm; m. 32.783 kg
Mold Mark(s):
a) L·PLANI L·F RVSSINI (cartouche l. 13.2 cm, w. 1.6 cm)
b) *anchor* (facing left; cartouche l. 6.2 cm, w. 1.5 cm)
Notes: No secondary marks reported. Inscription (a) interpreted as in 20.9.

20.11) Lead ingot RLM inv. MB 52.11
Type: D1a
Metrics: l. 45.5 cm, w. 9.4 cm, h. 10.4 cm; m. 32.816 kg
Mold Mark(s):
a) CN·ATELLI·T·F·MENE (NE in ligature; cartouche l. 22.2 cm, w. 1.8-2.0 cm)
Notes: No secondary marks reported. Inscription (a) interpreted as in 20.3.

20.12) Lead ingot RLM inv. MB 52.12
Type: D1c
Metrics: l. 43.5 cm, w. 9.7 cm, h. 9.8 cm; m. 30.668 kg
Mold Mark(s):
a) […] (cartouche l. 7.3 cm, w. 1.5 cm)
b) *dolphin* (facing left; cartouche l. 5.1 cm, w. 1.5 cm)
c) Ṛ S I (cartouche l. 7.2 cm, w. 1.5 cm)
Notes: No secondary marks reported. Inscription (c) interpreted as *R[u]s[sin]i*. With 3 cartouches and a dolphin, it most likely belongs to the Marcus Planius group.

21) Mal di Ventre
Alternate Names: Cabras(?)[664]
Region: Western Sardinia (IT) *BA* 48:A3
Date: ca. 89 - 50 B.C.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 981[665]

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664 Parker (1992a, 79) includes an entry for a wreck he calls "Cabras" based on the single mention of a cargo of ingots found there by Mocchegiani and Fozzati (1991, 78). As this region includes the island of Mal di Ventre and no other mention of a second Roman lead cargo in this area can be found, it is likely they are the same wreck.

665 Salvi (1992a, 661-2) originally reported a total of 854, but a later publication (Pinarelli et

Discussion: This site, discovered in 1988, represents the largest single find of Roman lead ingots so far found, totaling roughly 32 tons of metal. The ship was estimated to be 36 m in lenth, based on the spread of the ingots, which were arranged in longitudinal files along the lowest hull timbers on top of sheets of lead. A ship of this size would have been relatively large, with an overall capacity well over twice the weight of the ingots.[666] Since no other cargo was reported in conjunction with this wreck, it may have carried a perishable cargo on top of the ingots. The site also provides the largest attested consignment of a single mine's output, with over 74% of the ingots linked to the producers Marcus and Caius Pontilienus. Lead isotope analysis was performed on samples from 10 ingots, representing all nine groups outlined below; all isotope ratios are consistent with ores from the Cartagena region of southeastern Spain.

References: Salvi 1992a; Salvi 1992b; Parker 1992a, 256; Pinarelli et al. 1995, Salvi 1995.

21.1) 728 lead ingots

Type: D1a

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) SOC·M·C·PONTILIENORVM·M·F (NT in ligature; extra dot over the second C; cartouche l. 16 cm, w. 2 cm); or

Secondary Markings/Features:

b) PILIP (stamped on back of an unspecified number of ingots)

Notes: Inscription (a) interpreted as *Soc(ietas) M(arci et) G(aii) Pontilienorum M(arci) f(iliorum)*. See **16.4** for more information on the Pontilienus family. Inscription (b) has been interpreted as a slave (Philip) of the Pontilieni, due to the use of single name rather than a monogram.

21.2) 66+ lead ingots

Type: D1a?

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) M·C·PONTILIENORVM·M·F (NT not in ligature; cartouche l. 23 cm, w. 2 cm)

Secondary Markings/Features:

b) PILIP (stamped on an unspecified number of ingots)

Notes: Inscription (a) interpreted as *M(arci et) G(aii) Pontilienorum M(arci) f(iliorum)*. The lack of the *societas* designation, seen in the ingots of 21.1, may represent a change in organization of the Pontilieni's operation, with this smaller batch representing output left over from the previous system or the initial output of the new organization.

21.3) 83+ lead ingots

Type: D1c

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) Q·APPI (cartouche l. 7 cm, w. 2 cm)

b) *dolphin* (facing left ; cartouche l. 5.8 cm, w. 2 cm)

c) C·F *anchor* (cartouche l. 6.2 cm, w. 2 cm)

Notes: Inscription (a) and (c) interpreted together as *Q(uinti) Appi G(aii) f(ilii)*. The *gens* Appia is has been attested in Rome, but is relatively uncommon.

21.4) 54+ lead ingots

Type: D1a

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

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al. 1995) brings the number up to 981. The latter publication only gives a subtotal for the largest group of ingots (**21.1**); therefore quantities for other groups of ingots are based on the former publication with the understanding that these represent minimum numbers per group.

[666] Casson (1971, 171-3) suggests a minimum size of 70-80 tons for seagoing merchant vessels.

a) L·CARVLI·L·F·HISPALI·MN (a second reported dot above the F and H; cartouche l. 24 cm, w. 2 cm)

Notes: Inscription (a) interpreted as *L(ucii) Caruli(i) L(ucii) f(ilii) Hispali M(e)n(enia tribu)*. Ingots with this inscription have been found at land sites in northeastern Italy (Ostra Vetere) and Mallorca (La Puebla).[667] The name Carulius or Carullius, and the tribe Menenia, are primarily linked to southern Campania as well as the Praeneste region of Latium.[668]

21.5) Lead ingot

Type: D1b

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) [.]VTIVS [..] (cartouche l. 7.5 cm, w. 2 cm)

b) *dolphin* (cartouche l. 7.5 ? cm, w. 2 cm)

Notes: Inscription (a) interpreted as *G(aius) Utius G(aii) f(ilius)*. For more on the *gens* Utia, see 18.1. The use of the nominative rather than genitive form is rare on lead ingots, but is relatively common on Utius examples (cf. **18.1**, **23.3**, **26.1**, **27.13**).

21.6) Lead ingot

Type: D1a

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) CNATELLITFMEN (cartouche l. 14.5 cm, w. 2 cm)

Notes: Inscription (a) interpreted as *Cn(aei) Atelli T(iti) f(ilii)*. For more information on the *gens* Atellia see **20.3**.

21.7) Lead ingot

Type: D1c

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) Ḷ…NI (cartouche l. 7 cm)

b) *dolphin* (cartouche l. 5.5? cm)

c) RVSSINI (cartouche 7.7? cm)

Notes: Inscription (a) and (c) restored and interpreted together as *L(ucii) Plani(i) L(ucii) f(ilii) Russini*. For more information on the *gens* Plania see **16.2**.[669]

21.8) Lead ingot

Type: D1c

Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg

Mold Mark(s):

a) *caduceus* (cartouche l. 4.5 cm)

b) L·APPVLEI·L·L·PILON (cartouche l. 12.5 cm)

c) *dolphin* (cartouche l. 4.5 cm)

Notes: Inscription (b) interpreted as *L(ucii) Appulei L(ucii) l(iberti) Pilon(is)*. The gens Appuleia was well attested in Rome and Pompeii, and has been attested at least twice in Carthago Nova.[670] This is one of several examples of a freedman

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[667] Domergue et al. 1974, 119-121.

[668] Domergue et al. (1974, 129-30) point out that the name Carulius itself was often spelled Carullius, with the former spelling most commonly attested in Capua. On lead ingots, only examples with the single L have been found, perhaps indicating the producer had ties with this city.

[669] Another ingot with this same set of inscriptions was found under water off the coast of the island of Mal di Ventre and reported by Zucca (1985, 150-1), which may have come from this wreck. Its measurements are l. 44.5 cm, w. 8.7 cm, h. 9.7 cm; back l. 41 cm; first cartouche: l. 7.7, w. 2.2 cm; second: l. 5.5 cm, w. 2.3 cm, third: l. 7.5 cm, w. 2.3 cm; m. 33 kg. Zucca also reported a second ingot from a separate location with the mold mark *M·VAL … RECT* (VAL in ligature), and with a stamp on one face SEX·VL (VL in ligature); in both cases the punctuation point is triangular; measurements are: l. 46.2 cm, w. 13 cm., h. 12.1 cm.; back l. 41.9 cm; m. 52.75 kg. The *gens* Valeria is also attested on ingots from Cabrera E (**41**) and Sud Perduto B (**45**). Both are reported as having rounded backs, suggesting they are type D1.

[670] *CIL* 2, 03416 and 03447.

attested on lead ingots (cf. 16.3, 22.3-4, 25.1, 25.2).

21.9) Lead ingot
Type: D1c
Metrics: (average range) l. 46-47 cm, w. 8.5-9.5 cm, h. 8.5-9.5 cm; back l. 42-44 cm; m. 33 kg
Mold Mark(s):
a) *caduceus(?)* (cartouche l. 4.7 cm)
b) Ṃ APINARIMF (cartouche l. 8.5 cm)
c) *dolphin* (cartouche l. 6 cm)
Notes: Inscription (a) interpreted as *M(arci) Apinari M(arci) f(iliii)*. This name so far has no known parallels.

22) Capo Testa B
Alternate Names: Relitto del ferro
Region: Strait of Bonifacio (IT) *BA* 48:D3
Date: 75-25 BC
Cultural Affiliation: Roman
Number of Lead Ingots Found: 4
Discussion: Excavated in 1977-8, this wreck contained a primary cargo of iron bars, averaging 50-100 cm in length, 6 cm in height, scattered over an area 18 m by 8 m. Only four lead ingots were found, and no looting was reported, suggesting the ingots belonged to the ship's stores rather than cargo. The remains of lead sheathing, as well as two lead anchor stocks and a lead pipe were recovered, attesting to on-board lead use. With very few ceramic remains recovered, beyond the possible identification of a Dressel 1B amphora fragment, dating of the site is based heavily on the ingots and their parallels with more securely dated wrecks such as Mahdia (**20**) and Madrague de Giens (**23**).
References: Gianfrotta & Pomey 1980; Gandolfi 1985a; Parker 1992a, 125-6.

22.1) Lead Ingot C.T. 11
Type: D1a
Metrics: l. 45.8 cm, w. 9 cm, h. 11 cm; length of back 42 cm; cartouche 11.5 x 2.2 cm; 32.6 kg.
Mold Mark(s):
a) C·VTI·C·F·MENEN (cartouche: 11.5 x 2.2 cm; NE in ligature and both N's are reversed)
Notes: Found 11.5 m SW of the iron anchor at the extreme western end of wreck. Inscription (a) is interpreted as *G(aii) Uti(i) G(aii) f(ilii) Menen(ia tribu)*. For more details on the *gens* Utia see **21.5**.

22.2) Lead Ingot C.T. 29
Type: D1a
Metrics: l. 45 cm, w. 9 cm, h. 10 cm; length of back 42 cm; 32.7 kg.
Mold Mark(s):
a) C·VTI·C·F·MENEN (cartouche: 11.2 x 1.7 cm; NE in ligature and both N's are reversed)
Notes: Found 6.4 m NW of the iron anchor, near the center of wreck. Inscription (a) is interpreted as in 22.1.

22.3) Lead Ingot C.T. 29; DOM 1006
Type: D1a
Metrics: l. 45 cm, w. 9 cm, h. 11 cm; length of back 42 cm; 32.6 kg.
Mold Mark(s):
a) CN·ATELLI·CN·L·BVLIO (cartouche: 15 x 1.8 cm; VL in ligature)
Notes: Found 6.4 m NW of the iron anchor, near the center of wreck. Inscription (a) interpreted as *Cn(aeus) Atelli(us) Cn(aei) l(ibertus) Bulio*[671]. For details on the *gens* Atellia see **20.3**. Other ingots from Cn. Atellius himself include **20.4**, **20.11** and **21.6**. This ingot attests production by a freedman of the Atellius family, suggesting a satellite operation or perhaps his succecssion to the business at a time after the Cn. Atellius ingots were produced.[672] Bulio is also attested on an ingot from Capo Passero (**25.2**).[673]

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[671] Bulio is believed to be the nominative form of a local Spanish name, thus the inscription has been restored as being in the nomitave, as some Utius ingots are (21.5, 23.3, 26.1, 27.13).
[672] Other *liberti* of Cn. Atellius (or relatives of the same name) have been attested in this region, including Toloco (*CIL* 2, 3450) , Theofrastus (*CIL* 2, 3449) and Philoxenus (*CIL* 2, 3521) (Barreda Pascual 1998, 162-3).
[673] *Liberti* have also been attested on 16.3, 21.8, and 25.1)

22.4) Lead Ingot C.T. 1
Type: D1a
Metrics: not published
Mold Mark(s):
a) CN·ATELLI·CN·L·BVLIO (VL in ligature)
Notes: This ingot was heavily concreted and its dimensions were not published with the others, but the inscription was reported as being the same as that of 22.3.

23) Madrague de Giens
Region: Var (FR) *BA* 16:B3
Date: 60 – 50 BC
Cultural Affiliation: Roman
Number of Lead Ingots Found: 3 [674]
Discussion: This remarkably well-preserved ship, excavated between 1971 and 1983, carried over 7,500 wine amphorae (primarily Dressel 1B) and is estimated to have had a capacity of ca. 400 tons.[675] Secondary cargo included black glaze ware and Italian coarseware. A lead weight in the shape of an amphora was also found, weighing ca. 320 g, just short of one *libra*.

Only three lead ingots were found, two of which were positioned against ceiling planking above the top level of amphorae.[676] The names on the ingots have ties to Campania, as do some of the galleyware from the ship; while the origin of the lead, based on the inscriptions and lead isotope analysis, was most likely the Cartagena region of Spain, [677] the ship itself may have acquired the ingots in a Campanian port. Inventory number from the Dépôt des fouilles sous-marines d'Hyères (DHY).
References: Laubenheimer 1978, 69-72 (LL); Parker 1992a, 249-50.

23.1) Lead ingot LL 1978: 1
Type: D1a
Metrics: l. 45 cm, w. 9.5 cm, h. 9.8 cm; back l. 40 cm; m. 30 kg
Mold Mark(s):
a) …I·L·F… (cartouche l. 24.75 cm, w. 3.5 cm)
Notes: Inscription (a) is very poorly preserved and is restored as *…i L(uci) f(ilii)*; the position of the surviving letters, however, is consistent with the same letters found in 23.2(a).[678]

23.2) Lead ingot LL 1978: 2; Domergue et al. 1974: 4; DHY inv. Gi-73-C-673
Type: D1a
Metrics: l. 46.8 cm, w. 9.5 cm, h. 9.6 cm; back l. 43.4 cm; m. 31.2 kg
Mold Mark(s):
a) L·CARVLI·L·F[·]HISPALLI·MEN (cartouche l. 28.3 cm, w. 2.2 cm)
Notes: Inscription (a) is interpreted as *L(ucii) Caruli(i) L(ucii) f(ilii) Hispalli Men(enia tribu)*. For more details on the Carulius family, see 21.4. The name Hispalli has also been attested as Hispali (21.4), but retains the double L in **33.1**.

23.3) Lead ingot LL 1978: 3; DHY inv. Gi-73-B-213
Type: D1b
Metrics: l. 46.3 cm, w. 9.5 cm, h. 9.6 cm; back l. 44 cm; m. 31.2 kg
Mold Mark(s):
a) C·VTIVS·C·F (cartouche l. 8.8 cm, w. 2.2 cm)
b) *dolphin* (facing right; cartouche l. 6.1 cm, w. 2.2 cm)
Notes: Inscription (a) is interpreted as *G(aius) Utius G(aii) f(ilius)*. For more on the *gens* Utia, see **18.1**.

[674] Parker (1992a, 249) reports 5 ingots were found, but only 3 were listed in the field report (Laubenheimer and Lécaille 1978).
[675] This estimate is based on the probable presence of four layers of amphorae in the hold; if there were only three, it likely carried ca. 5,800 amphorae with a tonnage closer to 300 tons (Tchernia 1978, 103).
[676] The other ingot was found early on in the excavation and its original position is unknown.
[677] Lead isotope test results can be found in Trincherini et al. 2009, Table 1.
[678] The cartouche dimensions, however, are noticeably different, with 23.1(a) being over a centimeter wider than other known Carulius ingots (21.4, 23.2, 32.1).

24) Planier C

Alternate Names: Planier III

Region: Bouches-du-Rhône (FR) *BA* 15:E3

Date: ca. 60-40 B.C.E.

Cultural Affiliation: Roman

Number of Lead Ingots Found: none; litharge only

Discussion: This wreck, excavated between 1968 and 1975, carried a cargo of amphorae, primarily Dressel 1B, along with Panella 2 and Lamboglia 2. The ship was dated based on fragments of Arretine ware found at the site. In addition, litharge, realgar and blue frit were all found. While the first two were used for both pigments and medicines, blue frit was primarily used as a glaze or pigment, suggesting this shipment was destined for a workshop or pigment shop.

References: Tchernia 1968-70; 1969, 489; Parker 1992a, 316-7.

25) Capo Passero

Region: Sicily (IT) *BA* 47:G5

Date: ca. 40 BC

Cultural Affiliation: Roman

Number of Lead Ingots Found: 13

Discussion: Little information is currently available on this wreck site, discovered in 2006. Some evidence for the hull survived, including nails and sheathing, but the site had been disturbed by looters. No evidence for cargo beyond the lead ingots has been reported. It is not clear if further excavation is planned. Details about the ingots have so far only been published as groups, based on their stamps, with an average weight and size provided for the group as a whole.

References: Lopes 2006; Tisseyre et al. 2008; Carlo Beltrame in Delgado 2008, 333.

25.1) 4 Lead ingots

Type: D1c[679]

Metrics: l. 45-48 cm, w. 12 cm, height not given; average m. 33 kg

Mold Mark(s):

a) *caduceus*

b) M·OCT·M·L·PAPIL (AP in ligature)

c) *dolphin*

Secondary Markings: not given

Notes: No measurements given for cartouches or letter size. Inscription (b) interpreted as *M(arci) Oct(avii) M(arci) l(iberti) Papil(ioni?)*. Octavianus is a widely attested Roman family, originating in southern Latium and most renowned for its ties to the emperor Augustus. There are few attestations of this name from Carthago Nova, but one dedicatory inscription to a woman named Octavia, daughter of Marcus, could indicate ties to the region.[680] The producer, Papil(io?) was a freedman of this family.[681]

25.2) 1 Lead ingot

Type: D1a

Metrics: L. 45 - 48 cm, w. 12 cm, height not given; average m: 33 kg

Mold Mark(s):

a) CN·ATELLI·CN·L·BV[L]IO (VL in ligature[682])

Secondary Markings: not given

Notes: Inscription (a) interpreted as *Cn(aei) Atelli(i) Cn(aei) l(iberti) Bulio*, also attested on ingots from the Capo Testa B wreck (**22.3-4**). For details on the Atellius family see **20.3**.[683]

[679] The presence of three separate cartouches is not stated openly in Tisseyre et al. (2008), but can be deduced from their Figures 1 and 5.

[680] *CIL* 02, 03437. The full name as inscribed is *Octaviae M(arci) f(iliae) Lucanae dominae optimae*.

[681] For other examples of freedmen attested on lead ingots, see 16.3, 21.8, 22.3-4, and 25.2.

[682] Tisseyre et al. (2008, 317) published the final part of the inscription as “BVIO” rather than “BVLIO;” however, comparison with ingots from the Capo Testa B wreck (Gandolfi 1985, 320) have led me to restore the “L.” A photograph of the ingot (Tisseyre et al. 2008, Fig. 2) shows that this section of the stamp is somewhat obscured, perhaps due to damage or concretion, so such a ligature may have been easily lost or overlooked.

[683] Atellius has also been attested on 20.11 and 21.6.

25.3) 8 Lead ingots
Type: D1c
Metrics: L. 45- 48 cm, w. 12 cm, height not given; m: 33 kg
Mold Mark(s):
a) MPLANII
b) *dolphin*
c) RV.. IN.
Secondary Markings: not given
Notes: Inscriptions (a) and (c) interpreted altogether as *M(arci) Planii Ru[ss]in[i]*[684] See **16.2** for more information on the *gens* Plania.

26) Punta Falcone
Alternate Names: Punta Capo Falcone
Region: Western Sardinia (IT) *BA* 48:A2
Date: 100-25 BC (?)
Cultural Affiliation: Roman
Number of Lead Ingots Found: 16
Discussion: There has been very little information published about this wreck, discovered in 1968. The primary cargo and associated artifacts are unknown. The ingots are of Republican form and the inscriptions, all lacking a *cognomen*, are also indicative of the Republican period. Inventory numbers are from Museo Nazionale G. A. Sanna di Sassari (MNS).
References: Tylecote et al. 1983, 73; Boninu 1986, 57; Parker 1992a, 353.

26.1) 16 lead ingots MNS inv. 10210-10225
Type: D1b
Metrics: dimensions not published; m. approx 31 kg each.
Mold Mark(s):
a) C·VTIVS·C·F
b) *dolphin* (facing right)
Secondary Markings/Features: none confirmed
Notes: Inscription (a) interpreted as *G(aius) Utius G(aii) f(ilius)*. For details on the *gens* Utia, see **18.1**.

27) Bajo de Dentro
Alternate names: Cabo de Palos
Region: Murcia (ES) *BA* 27:E4
Date: 1st c. BC
Cultural Affiliation: Roman
Number of Lead Ingots Found: 49 (per Parker) or 42 (per Más)
Discussion: The site appears to reflect a sunken lead cargo, although no hull remains have been reported. Two large lead anchor stocks were discovered in the area at the beginning of the 20th century, but cannot be directly tied to the ingots.

Six ingots were recovered in 1953, and 15 were discovered in 1965 on a training dive by Spanish naval divers. Information on the recovery of the additional ingots is unclear and inscriptions are reported only summarily. Parker reports a Lamboglia 2 amphora and several anchor stocks were found nearby. No depth was reported, so the likelihood of salvage of the site in ancient times is unkown. Ingot details were reported most comprehensively by Domergue on the group of 15. No secondary markings were reported. Lead isotope analysis confirms the ingots originated in the Sierra de Cartagena.[685]
References: Domergue 1966; Más 1972, 72; Más 1985, 162-3; Parker 1992a, 65-6.

27.1) 1 Lead ingot Domergue 1966: 1
Type: D1a
Metrics: l. 46.9 cm, w. 9.4 cm, h. 8.7 cm; back l. 43.5 cm; m. 31 kg
Mold Mark(s):
a) M·AQVINI·C·F (cartouche l. 10.1 cm, w. 2.2; mlh 1.2 cm; N is reversed)
Notes: Inscription (a) interpreted as *M(arci) Aquini(i) C(aii) f(ilii)*. The tail of the Q is straight and horizontal, and the strokes of the M are of equal length and in parallel pairs, which are typical of the late

[684] The original publication (Tisseyre et al. 2008) lists “Marcius Planius Russinius” but this is inconsistent with other Planii ingots found elsewhere, which are generally in the genitive (cf. Domergue 1965). No photograph of cartouche 25.3(a) was published, but if their transcription is accurate, this is the only instance of the use of *PLANII* rather than *PLANI*. Other errors in the text, however, indicate that confirmation should be made before accepting this reading.

[685] Trincherini et al. 2009, Table 1.

Republic inscriptions. For more details on this *gens* see **17.1**.

27.2) Lead ingot Domergue 1966: 2
Type: D1a
Metrics: l. 46.7 cm, w. 9.4 cm, h. 8.8 cm; back l. 43.3 cm; m. 31.25 kg
Mold Mark(s):
a) M·AQVỊṆI·Ç Ḟ (cartouche l. 10.1 cm, w. 2.2; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1.

27.3) Lead ingot Domergue 1966: 3
Type: D1a
Metrics: l. 46.6 cm, w. 8.7 cm, h. 8.4 cm; back l. 43.5 cm; m. 29.6 kg
Mold Mark(s):
a) M·AQṾỊNỊ·Ç Ḟ (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1.

27.4) Lead ingot Domergue 1966: 4
Type: D1a
Metrics: l. 46.5 cm, w. 9.3 cm, h. 8.8 cm; back l. 43.3 cm; m. 30.7 kg
Mold Mark(s):
a) Ṃ·ẠQ̣[VI]ṆỊ·C·F (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1.

27.5) Lead ingot Domergue 1966: 5
Type: D1a
Metrics: l. 46.2 cm, w. 8.9 cm, h. 8.6 cm; back l. 43.3 cm; m. 28.95 kg
Mold Mark(s):
a) Ṃ·[AQVINI·]C·F (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1 though very little of it remains.

27.6) Lead ingot Domergue 1966: 6
Type: D1a
Metrics: l. 46.9 cm, w. 9.3 cm, h. 9 cm; back l. 43.5 cm; m. 30.6 kg
Mold Mark(s):
a) Ṃ·Ạ[QVI]N[I] Ç·Ḟ (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1.

27.7) Lead ingot Domergue 1966: 7
Type: D1a
Metrics: l. 46.5 cm, w. 9.4 cm, h. 9 cm; back l. 43.8 cm; m. 31.95 kg
Mold Mark(s):
a) Ṃ·Ạ[QVINI·C·F] (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1, though only the first two letters are preserved.

27.8) Lead ingot Domergue 1966: 8
Type: D1a
Metrics: l. 46.7 cm, w. 9.6 cm, h. 8.6 cm; back l. 43.7 cm; m. 30.5 kg
Mold Mark(s):
a) Ṃ·ẠQ[VI]ṆỊ Ç Ḟ (cartouche l. 10.3 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1.

27.9) Lead ingot Domergue 1966: 9
Type: D1a
Metrics: l. 46.5 cm, w. 9 cm, h. 8.3 cm; back l. 42.6 cm; m. 30.1 kg
Mold Mark(s):
a) Ṃ [A]Q[VINI·C·F] (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1.

27.10) Lead ingot Domergue 1966: 10
Type: D1a
Metrics: l. 46.5 cm, w. 9.4 cm, h. 8.9 cm; back l. 43.6 cm; m. 30.45 kg
Mold Mark(s):
a) [M·A]Q[VINI·C·F] (cartouche l. 10.1 cm, w. 2.2 cm; mlh 1.2 cm)
Notes: Inscription (a) is interpreted as in 27.1, despite the loss of nearly all the letters, based heavily on the cartouche dimensions, which are consistent with others from the Aquinus series.

27.11) Lead ingot Domergue 1966: 12
Type: D1a
Metrics: l. 45.8 cm, w. 9.3 cm, h. 8.9 cm; back l. 43.2 cm; m. 32.5 kg
Mold Mark(s):
a) Ṃ ….. Ị M·Ḟ (cartouche l. 14.2 cm, w. 2.3 cm)
Notes: Cartouche is flanked by two crescents and was heavily concreted.

Domergue interprets (a) as *M(arci) …..i M(arci) f(ilii)*; it may correspond to the inscription listed by Más as associated with this wreck: M·SEX·CALVI·M·F.

27.12) Lead ingot Domergue 1966: 13
Type: D1b
Metrics: l. 46.4 cm, w. 9.8 cm, h. 9 cm; back l. 43.2 cm; m. 31.95 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 6.4 cm, w. 2.2 cm)
b) C·MẸṢṢI·Ḷ·F (cartouche l. 9.5 cm, w. 2.2 cm)
Secondary Markings/Features: None reported
Notes: Inscription (b) is largely illegible but restored by Domergue based on an ingot fragment found in Italy.[686] It is interpreted as *G(aii) Messi(i) L(ucii) f(ilii)*. The *gens* Messia derives from the Oscan language and is widely attested in Italy, particularly in Campania, where the Oscan tribe originated.

27.13) Lead ingot Domergue 1966: 15
Type: D1c
Metrics: l. 48.9 cm, w. 9.2 cm, h. 9 cm; m. 32.5 kg
Mold Mark(s):
a) *dolphin* (facing right; cartouche l. 5 cm, w. 2 cm)
b) C·VTIVS·C F (cartouche l. 11.4 cm, w. 2.1 cm)
c) *caduceus* (cartouche l. 5 cm, w. 2 cm)
Secondary Markings/Features: None reported
Notes: Inscription (b) interpreted as *C(aius) Utius G(aii) filius*. For more information on the *gens* Utia see **18.1**.

27.14) Lead ingot Domergue 1966: 29
Type: D1c
Metrics: l. 46 cm, w. 9.1 cm, h. 8.4 cm; back l. 42.8 cm; m. 30.65 kg
Mold Mark(s):
a) Ḷ P̣Ḷ …. Ḷ F̣ (cartouche l. 7.7 cm, w. 2.2 cm)
b) *dolphin* (head to the right, cartouche l. 5.5 cm, w. 2.3 cm)
c) […] (cartouche l. 7.1 cm, w. 2.2 cm)
Notes: Cartouche (a) is restored as *L(ucii) Pl[ani] L(ucii) f(ilii)*; the three cartouches are relatively similar in size and evenly spaced, with a possible final I in the third, to be restored as [RVSSIN]I, as attested on similar examples found elsewhere. See **16.2** for more information on the Planii.

27.15) Lead ingot Domergue 1966: 30
Type: D1c
Metrics: l. 46.5 cm, w. 10 cm, h. 9.2 cm; back l. 42.8 cm; m. 32.5 kg
Mold Mark(s):
a) […] (cartouche l. 7.7 cm, w. 2.2 cm)
b) *dolphin* (head to the right, cartouche l. 5.5 cm, w. 2.8 cm)
c) […]Ị (cartouche l. 7.1 cm, w. 2.5 cm)
Notes: Inscriptions (a) and (c) are interpreted as in 27.14 due to similarities in cartouche dimensions and the presence of the dolphin in (b).

28) Cala Cartoe *BA* 48:B2
Region: Eastern Sardinia (IT)
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 1
Discussion: This was an isolated find from the gulf of Orosei, recovered in 1978. No associated artifacts were found, and dating is based upon the ingot shape and inscription. The ingot is one of very few recovered from the east coast of Sardinia.
References: Boninu 1985; Parker 1992a, 87.

28.1) Lead ingot
Type: D1b
Metrics: l. 46.5 cm, w. 9 cm, h. 8 cm; m. 29.3 kg
Mold Mark(s):
a) L·PLAANI·LF
b) RVSSINI
Notes: Inscriptions (a) and (b) are interpreted together as *L(ucii) Plaani(i) L(ucii) f(ilii) Russini*. This most likely represents the same individual or a member of the same family as attested in ingots **16.2**, **17.3**, **20.2**, **20.5-10**, **21.7**, **25.3**, **27.14-15**, **30.14**, and **31.1**, although the spelling is thus far unique. The ingot

[686] Cited by Domergue (1966, note 35) as *CIL* XI 6722, 13.

is also rather shorter, and thus lighter, than other Planius ingots, suggesting perhaps a slightly earlier, less standardized product.

29) Cap Spartel

Region: Tangier-Tétouan (MA) *BA* 28:C2
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 40+ (only 10 recovered)
Discussion: This wreck was discovered in 1962, in a high energy environment, which limited the extent of the excavation. In addition to lead ingots, this wreck contained a lead anchor stock, several lengths of lead pipe,[687] and a bar of lead (l. 62 cm, w. 6 cm) with a rectangular section, but bent and crushed in the center (cf. Bajo de la Campana (**5**), Lavezzi A (**48**)). No other associated cargo was reported. The neck of a Dressel 8 amphora, common to the second century C.E., was found nearby but may have been intrusive. This is the only ancient lead wreck so far known on the Atlantic coast of North Africa and it may have been destined for Tingis (modern Tangier), founded by the Carthaginians and subsequently under Roman control.

Ten ingots were recovered by divers, while at least thirty were left in situ. The shape of the ingots is more typical of the late Republic or early Empire, although their lack of mold marks is unusual.[688] Ponsich makes a case for the lead's origin being the North African mines of Beni Maden or Coudiat es Taifor, both not far from Cap Spartel, but on the Mediterranean coast of Morocco rather than the Atlantic. The ingot shape, however, remains consistent with Iberian production.
References: Ponsich 1966; Euzennat 1971; Parker 1992a, 107.

30) Cartagena B

Region: Murcia (ES) *BA* 27:E4
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 14-16[689]
Discussion: This group of ingots was found in 1962-3 in Cartagena. No hull or additional cargo was found, suggesting the ingots may have been jettisoned or, if there was a wreck, that the primary cargo was organic in nature and did not survive.
References: Domergue 1966; Más 1972, 73-4 and figs. 67-8; Parker 1992a, 130.

30.1) Lead ingot Domergue 1966:14
Type: D1b
Metrics: l. 46.5 cm, w. 9.8 cm, h. 9; back l. 43.3; m. 32.3 kg
Mold Mark(s):
a) Ç·FIDVI·C F (cartouche l. 10 cm, w. 2.1 cm)
b) Ṣ·Ḷ[VC]ṚETI·S·F (cartouche l. 10 cm, w. 2 cm)
Notes: Inscription (a) interpreted as *G(aii) Fidui(i) G(aii) f(ilii)*, and (b) as *S(purii) Lucreti(i) S(purii) f(ilii)*. Domergue prefers Spurii to Sexti in this case.[690]

30.2) Lead ingot Domergue 1966:16
Type: D1c
Metrics: l. 45 cm, w. 9.5 cm, h. 8 cm; back l. 41.2 cm; m. 30.25 kg
Mold Mark(s):
a) *dolphin* (head facing right; cartouche l. 5 cm, w. 2.8 cm)
b) C·AQVINI·M·F (cartouche l. 13 cm, w. 2.4 cm)
c) *anchor* (point to the left; cartouche l. 5 cm, w. 2.8 cm)

687 Two were reported in detail (Ponsich 1966, 1276): a) 1. 10 cm, d. 11 cm, thickness 0.9 cm; b) l. 12 cm, d. 5 cm, thickness 0.4 cm. Both had a raised exterior weld typical of Roman pipes.
688 See Ponsich (1966, Fig. 1.3), which shows an ingot with a rounded back but straight sides, suggesting type D2, rather than the parabolic cross section of the D1. Uninscribed ingots were also found at Algajola (**15**) and La Chrétienne A (**31**), both believed to be of early first century B.C.E. date due to the presence of Dressel 1A amphora remains.
689 Domergue (1966) reports 14 ingots, Más (1972) 16 and Parker (1992a) 15.
690 Domergue 1966, 50

Notes: Inscription (b) interpreted as *G(aii) Aquini(i) M(arci) f(ilii)*. The tail of the Q is straight and horizontal, and the strokes of the M are of equal length and in parallel pairs.

30.3) Lead ingot Domergue 1966:17
Type: D1c
Metrics: l. 45 cm, w. 9.8 cm, h. 9.7 cm; back l. 41.2 cm; m. 30.5 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 5.2[691] cm)
b) C·AQVINI·M·F (cartouche l. 12.9 cm, w. 2.2 cm)
c) *anchor* (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. The dolphin is very deteriorated.

30.4) Lead ingot Domergue 1966:18
Type: D1c
Metrics: l. 45 cm, w. 9.5 cm, h. 8.7 cm; back l. 41.1 cm; m. 29.25 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 2.8 cm)
b) C·AQVINI·M·F (cartouche l. 13 cm, w. 2.2 cm)
c) …… (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Dolphin in (a) is incomplete and anchor is supplied for (c) by comparison to the other ingots.

30.5) Lead ingot Domergue 1966:19
Type: D1c
Metrics: l. 45.1 cm, w. 9.8 cm, h. 9.4 cm; back l. 41.5 cm, m. 31 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 4.8 cm, w. 2.8 cm)
b) C·AQVINI·Ṃ·F̣ (cartouche l. 13 cm, w. 2.2 cm)
c) *anchor* (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Very well preserved.

30.6) Lead ingot Domergue 1966:20
Type: D1c
Metrics: l. 44.5 cm, w. 9.5 cm, h. 9.4 cm; back l. 41 cm; m. 29.5 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 2.8 cm)
b) C·AQVINI·Ṃ·F̣ (cartouche l. 12.9 cm, w. 2.2 cm)
c) …… (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Dolphin in (a) is indistinct and anchor is supplied for (c) by comparison.

30.7) Lead ingot Domergue 1966:21
Type: D1c
Metrics: l. 45 cm, w. 9.5 cm, h. 9.3 cm; back l. 41 cm; m. 30 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 2.8 cm)
b) C̣ ẠQVINI·M·F (cartouche l. 13 cm, w. 2.3 cm)
c) *anchor* (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Dolphin in (a) is unrecognizable and anchor in (c) is incomplete.

30.8) Lead ingot Domergue 1966:22
Type: D1c
Metrics: l. 45.2 cm, w. 9.6 cm, h. 9.6 cm; back l. 41.2 cm; m. 31.25 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 2.8 cm)
b) C·AQṾỊṆỊ Ṃ F̣ (cartouche l. 13 cm, w. 2.2 cm)
c) *anchor* (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Anchor in (c) is barely visible.

30.9) Lead ingot Domergue 1966:23
Type: D1c
Metrics: l. 44 cm, w. 9 cm, h. 9 cm; back l. 41 cm; m. 28.25 kg
Mold Mark(s):
a) ...... (cartouche l. 5 cm, w. 2.8 cm)
b) C̣ Ạ[Q]Ṿ[IN]I Ṃ [F] (cartouche l. 13 cm, w. 2.2 cm)
c) ...... (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Surface is heavily deteriorated. Dolphin and anchor are presumed for (a) and (c).

[691] This number is extremely inconsistent with the other cartouche widths in the group and may be a typographical error.

30.10) Lead ingot Domergue 1966:24
Type: D1c
Metrics: l. 44.5 cm, w. 9 cm, h. 9.2 cm; back l. 40.5 cm; m. 27.25 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 2.8 cm)
b) C̣ [A]QṾ[INI] Ṃ [*F*] (cartouche l. 13 cm, w. 2.8 cm)
c) ...... (cartouche l. 5.3 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Surface very corroded. Anchor is supplied for (c) by comparison.

30.11) Lead ingot Domergue 1966:25
Type: D1c
Metrics: l. 44.6 cm, w. 9.4 cm, h. 9.1 cm; back l. 41 cm; m. 31.5 kg
Mold Mark(s):
a) ...... (cartouche l. 5 cm, w. 2.8 cm)
b) [C AQVINI] Ṃ·F (cartouche l. 13 cm, w. 2.6 cm)
c) ...... (cartouche l. 5.5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Dolphin is supplied for (a) and anchor for (c) by comparison.

30.12) Lead ingot Domergue 1966:26
Type: D1c
Metrics: l. 42.5 cm, w. 9.2 cm, h. 9.7 cm; back l. 41 cm; m. 27.25 kg
Mold Mark(s):
a) ...... (cartouche l. 5 cm, w. 2.8 cm)
b) C̣·Ạ Q̣[VINI·M·F] (cartouche l. 13.3 cm, w. 2.7 cm)
c) *anchor* (cartouche l. 5 cm, w. 2.8 cm)
Notes: Inscription (b) is interpreted as in 30.2. Dolphin is supplied for (a). One end appears to have been cut vertically, explaining its relatively low weight.

30.13) Lead ingot Domergue 1966:27
Type: D1c
Metrics: l. 44.8 cm, w. 9 cm, h. 9.2 cm; back l. 41 cm; m. 27.25 kg
Mold Mark(s):
a) *dolphin* (cartouche l. 5 cm, w. 2.8 cm)
b) [C·AQVINI·M·F] (cartouche l. 13 cm, w. 2.8 cm)
c) ...... (cartouche l. 5 cm, w. 2.8 cm)
Notes: Ingot is heavily corroded. Inscription (b) is restored as in 30.2, based on comparison to others in the group, linked by presence of (a) and similarity of metrics. Anchor is supplied for (c).

30.14) Lead ingot Domergue 1966:28
Type: D1c
Metrics: l. 45.5 cm, w. 10 cm, h. 8.5 cm; back l. 42.3 cm; m. 32.5 kg
Mold Mark(s):
a) L·PLANI L· F (cartouche l. 7.9 cm, w. 2 cm)
b) *dolphin* (cartouche l. 5.2 cm, w. 2 cm)
c) Ṛ[VSSINI] (cartouche l. 7.4 cm, w. 2.8 cm)
Notes: Inscription (a) interpreted as *L(ucii) Plani(i) L(ucii) f(ilii)*, and (c) restored as *Russini* based on comparison to other known Planii ingots (cf. **16**).

31) La Chrétienne A
Region: Var *BA* 16:C3
Date: early 1st c. B.C.E.
Cultural Affiliation: Roman[692]
Number of Lead Ingots Found: 1
Discussion: This site was heavily looted after its discovery in 1948, but the primary cargo appears to have been over 2,000 Dressel 1A amphorae, presumably containing wine. One lead ingot was recovered from looters by police, and no other metals were part of the cargo. There was no indication of lead sheathing, but a lead anchor stock and two lead-capped timbers indicate lead was used on board, suggesting the ingot was part of the stores and not part of a missing cargo. The ingot, which does not survive today, was reported as being without inscription. No description of shape was given, so no type can be assigned, though based on the date of the wreck, it was likely either a D1 or a B1.3 similar to those found on the Comacchio wreck (**39**).
References: Dumas 1972, 155-172; Pomey et al. 1987-8, 42; Parker 1992a, 140.

[692] A Pantellarian coin, found by Dumas (1972, 160) in the mast step, bore a Phoenician inscription, but was dated to ca. 75 B.C.E., at which point Rome controlled the island.

32) Dénia

Region: Valencia *BA* 27:F3
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 1
Discussion: This isolated ingot was discovered in 1978. No hull remains or associated artifacts were reported. It was dated based on ingots with the same inscription from elsewhere (see **16.2**). This location, ancient Dianium, was home to a naval base under the general Q. Sertorius in the first century B.C.E and was also close to iron mines.[693] Lead may have been imported there for fleet maintenance or simply passed through on its way from Carthago Nova either north toward Massalia or east through the Balearic Islands.[694]
References: Aranegui Gascó and Martín Bueno 1995.

32.1) Lead ingot
Type: D1c
Metrics: l. 42.5 cm, w. 9 cm, h. 9 cm; m. approx. 34 kg
Mold Mark(s):
a) L·PLANI·L·F
b) *dolphin* (inverted, facing left)
c) RVSSINI
Notes: Inscriptions (a) and (c) taken together and interpreted as *L(ucii) Plani(i) L(ucii) f(ilii) Russini*. For more information on the Planii see **16.2**. No secondary marks were reported.

33) Les Moines

Alternate names: Les Moines 2?
Region: Western Corsica (FR) *BA* 48:C3
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 1
Discussion: This isolated ingot, discovered in 1972, was found in association with amphora fragments, including a Lamboglia 2 neck. No further evidence of a wreck was discovered at the time. The site is dated roughly based on the shape of the ingot and its inscription, parallels of which were found on other Republican wrecks (cf. **21.4** and **23.2**). A nearby wreck (Les Moines 2) with amphorae of Spanish origin dating from this period, found in 1993, is likely be the origin of this ingot, but it cannot be proven.
References: Domergue et al. 1974, 123; Parker 1992a, 278; Bernard 2004, 75.

33.1) Lead ingot Domergue et al. 1974: 3
Type: D1a
Metrics: l. 45.5 cm, w. 9 cm, h. 9.5 cm; back l. 41.7 cm; mlh. 1.2-1.3 cm; m. 30.35 kg
Mold Mark(s):
a) ….. Ḟ[·]HISPAL..MEN (cartouche l. 19 cm, w. 2.1 cm)
Notes: The inscription is heavily damaged, but can be restored based on parallels as [*L(ucii) Carul(i)i L(ucii)*] *f(ilii) Hispal[i] Men(enia tribu)*. For details on the *gens* Carulia, see **21.4**.

34) Les Moines 3

Region: Western Corsica (FR) *BA* 48:C3
Date: 1st c. B.C.
Cultural Affiliation:
Number of Lead Ingots Found: 3
Discussion: Three isolated ingots were found in 1970 in the vicinity of a wreck scatter at the base of a sandbar. The ingots are type D1b, with one short and one long cartouche, but the inscriptions are no longer legible. The base of one is severely eroded. Based on the type, they are presumed to be of Republican date. The neck of a Gauloise 4 amphora was found nearby but may not be related, since these were produced between the late first through mid third centuries C.E. Isotopic analysis links the ingots to the ingots to the Sierra de Cartagena region.[695]
References: Bernard 2004, 77.

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[693] Strabo 3.4.6.
[694] Pliny (*HN* 3.11) points out that Dianium is equidistant from Carthago Nova and Ibiza in the Balearic Islands, an important eastward sailing route.
[695] Trincherini et al. 2009, Table 2.

35) Pointe de Bonnieu

Alternate names: Martigues
Region: Bouches-du-Rhône (FR) *BA* 15:E3
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 1
Discussion: This isolated ingot was found in 1989 at a depth of 10 m off Pointe de Bonnieu near the mouth of the Rhône. There was no other associated cargo or hull remains. The date is based on the shape of the ingot as well as details about its inscription. Isotopic analysis suggests the lead originated from the Sierra de Cartagena region.[696]
References: Pomey et al. 1992, 26.

35.1) Lead ingot

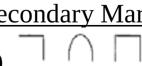
Type: D1a
Metrics: l. 46 cm, w. 9 cm, h. 9 cm; m. 30.2 kg.
Mold Mark(s):
a) A·P·FVRIEIS·C·P·L·L (cartouche l. 11.5 cm, w. 3.5 cm)
Notes: No secondary markings reported. Inscription (a) interpreted as *A(ulus et) P(ublius) Furieis C(ai et) P(ubli et) L(uci) l(iberti)*. Furieis is an early form of the nominative plural form *Furii*, suggesting an early date for the ingot. In addition, the inscription lacks a *cognomen*, a naming convention widely adopted by the late Republic, also supporting an early date. This family name also appears to be attested in the Comacchio wreck (cf. **39.10**).

36) Sanguinaires B

Region: Western Corsica (FR) *BA* 48:C3
Date: 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 7
Discussion: First reported in 1991, no cargo or hull remains were found at this site beyond the seven ingots and an iron concretion. A lead anchor stock was found to the southwest with a group of amphora sherds, but these are not believed to be connected to the ingots.

Five ingots were found roughly in a group, with two others close together approximately 4 m away. All were heavily concreted; six were cleaned and one was left in its original state. All had cartouches that take up the full width of the back with no lateral edges, but contain no mold marks. The cartouches are all very close in size, suggesting they all came from the same producer. Based on their shape, a Republican date is assumed. A single square hole halfway down the side of each ingot is likely the result of perforation with a nail, possibly related to lading, although these are so far the only Republican examples of this phenomenon (cf. **41**, **45**, **48**, **57**).
References: Alfonsi and Gandolfo 1993 (A&G).

36.1) Lead ingot A&G 1

Type: D1a
Metrics: l. 43.5 cm, w. 10.2 cm, h. 10.3-10.4 cm; back l. 39.3 cm; m. 32 kg
Mold Mark(s):
a) […] cartouche l. 12.2 cm, w. 3.6 cm
Secondary Markings/Features:
b)  (stamped on front face)
Notes: Inscription (b) may be interpreted as the Greek letters ΓΩΠ (with the gamma reversed). A slightly oblique nail hole (1.0 cm x 1.4 cm) penetrates front face through base, slightly forward, 21 cm from end.

36.2) Lead ingot A&G 2

Type: D1a
Metrics: l. 43.5 cm, w. 9.2-10 cm, h. 9.2-10.2 cm; back l. 39.2 cm; m. 28 kg
Mold Mark(s):
a) [….] cartouche l. 12.5 cm, w. 3.5 cm
Notes: An oblique nail hole (1.1 cm x 1.5 cm) penetrates front face through base, angled forward, 23.5 cm from end. This is the most noticeably assymetrical ingot of the group, with the left side a full centimeter higher than the right.

36.3) Lead ingot A&G 3

Type: D1a

[696] Trincherini et al. 2009, Table 1.

Metrics: l. 43.3-43.6 cm, w. 9.5-9.8 cm, h. 10.2 cm; back l. 39.2 cm; m. 30 kg
Mold Mark(s):
a) […] cartouche l. 12.6 cm, w. 3.9 cm
Notes: An oblique nail hole (1.4 cm x 1.4 cm) penetrates front face through base, angled forward, 23.5 cm from end. Hole exposed, possibly due to corrosion.

36.4) Lead ingot A&G 4
Type: D1a
Metrics: l. 43.7 cm, w. 9.7-9.9 cm, h. 10.5 cm; back l. 39.3 cm; m. 30 kg
Mold Mark(s):
a) […] cartouche l. 12.3 cm, w. 3.7 cm
Notes: A slightly oblique nail hole (1.4 cm x 1.6 cm) penetrates front face through base, angled forward, 23.5 cm from end. An anomalie at one end of the hole appears to be the impression of the nail head. Hole exposed, possibly due to corrosion.

36.5) Lead ingot A&G 5
Type: D1a
Metrics: l. 43.8 cm, w. 10.1 cm, h. 10.3-10.8 cm; back l. 39.4 cm; m. 32 kg
Mold Mark(s):
a) […] cartouche l. 12.5 cm, w. 4.0 cm
Notes: A slightly oblique nail hole (1.1 cm x 1.4 cm) penetrates front face through base, angled backward, 20.5 cm from left end. Hole exposed, possibly due to corrosion.

36.6) Lead ingot A&G 6
Type: D1a
Metrics: l. 44 cm, w. 10 cm, h. 10.6 cm; back l. 39.2 cm; m. 33 kg
Mold Mark(s):
a) […] cartouche l. 11.6 cm, w. 3.8 cm
Notes: An oblique nail hole (1.2 cm x 1.6 cm) penetrates front face through base, angled backward, 24.9 cm from end.

36.7) Lead ingot A&G 7
Type: D1a
Metrics: l. 43.8 cm, w. 9.9 cm, h. 9.8-10.6 cm; back l. 39.5 cm; m. 33 kg
Mold Mark(s):
a) […] cartouche l. 11.2 cm, w. 3.8 cm
Notes: This ingot was not cleaned as a record of their original state. No nail hole was apparent but may have been covered by concretion.

37) Scoglio Businco
Alternate names: sometimes confused with Punta Falcone, which is a separate wreck[697]
Region: Western Sardinia (IT) *BA* 48:A2
Date: 1st c. B.C.E.(?)
Cultural Affiliation: Roman
Number of Lead Ingots Found: 7
Discussion: Seven ingots were discovered at this site, between 1966 and 1967. Traces of a wreck were found nearby but no details on the hull or additional artifacts were reported beyond a lead anchor stock. The ingots are tentatively dated to the late Republic based on the ingot type. The site is not far from the silver-mining town of Argentiera, but the ingot shapes are typical of Spanish production. No lead isotope data has been published. Inventory numbers from Museo Nazionale di G. A. Sanna di Sassari (MNS).
References: Contu 1967, 206; Boninu 1986, 55; Parker 1992a, 390.

37.1) 7 lead ingots MNS inv. 9982, 10145, 10146, 10204-10207
Type: D1a
Metrics: (av. for group) l. 40 cm, w. 10 cm, h. 9 cm; m. 31 kg[698]
Secondary Mark(s):
(a) CERDO (stamped(?) on one face)
Notes: Two ingots have a cartouche on the back but lack legible insciptions, one of which also bears (a); the other five did not have surviving cartouches but were reported to be the same general size and shape as the others. Boninu suggests (a) was the name of a slave or a freedman, but it is more likely the name of a merchant. The name CERDO has also been found in an amphora stamp originating in Dugenta in Campania.[699]

[697] Parker 1992a, 390.
[698] Contu (1967) reports 30 kg, while Boninu (1986) reports 31 kg. Since Boninu also reports a revised inscription, I have accepted her data as current.
[699] Hesnard et al. 1989, 29.

38) Gavetti

Region: Strait of Bonifacio (IT) *BA* 48:D3
Date: Late 1st c. B.C.E.?
Cultural Affiliation: Roman
Number of Lead Ingots Found: 9
Discussion: These ingots were found in 1958 as an isolated group on the sea floor. No hull or associated cargo were reported. The date is suggested only by association with other ingots of similar shape from other sites. All ingots bear cartouches but are heavily deteriorated, so their measurements are not precise; only one (**38.9**), now lost, was reported to have any discernible letters. The eight remaining ingots were tested chemically, revealing the presence of copper, bismuth, and antimony, suggesting that the lead had been desilvered,[700] although some silver did remain. Inventory numbers cited are from Musée d'Ethnographie, Bastia (MEB) and Musée des Docks Romains, Marseille (MDR).
References: Benoit 1960; *LLGS* 96-111; Parker 1992a, 188.

38.1) Lead Ingot LLGS 1; MEB inv. D 64.166.1
Type: D2c
Metrics: l. 44.5 cm, w. 8.5 cm, h. 9.5 cm; back: 1. 39.5 cm; m: 28 kg
Mold Mark(s):
(a) [….] (l. 6 cm, w. 2 cm)
(b) [….] (l. 12.5 cm, w. 2 cm)
(c) [….] (l. 6 cm, w. 2 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Sb, Ag, Bi, and traces of Ni and Fe.

38.2) Lead Ingot LLGS 2, MEB inv. D 64.170.1
Type: D2c
Metrics: l. 43.5 cm., w. 8.5 cm, h. 9.5 cm; back l. 39.5 cm; m: 25 kg
Mold Mark(s):
(a) [….] (l. 6 cm, w. 2 cm)
(b) [….] (l. 13.5 cm, w. 2 cm)
(c) [….] (l. 6 cm, w. 2 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Sb, Ag, Bi, and traces of Ni.

38.3) Lead Ingot LLGS 3; MEB inv. D 64.171.1
Type: D2c
Metrics: l. 44 cm, w. 9.5 cm, h. 10 cm; back: 1. 39.5 cm; m: 26 kg
Mold Mark(s):
(a) [….] (l. 6 cm, w. 2 cm)
(b) [….] (l. 13.5 cm, w. 2 cm)
(c) [….] (l. 6 cm, w. 2 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Ag, Bi, and traces of Ni, and Sb.

38.4) Lead Ingot LLGS 4; MEB inv. D 64.168.1
Type: D2c
Metrics: l. 43 cm, w. 8.5 cm, h. 9 cm; back l. 40 cm; m: 25 kg
Mold Mark(s):
(a) [….] (l. 6.5 cm, w. 2 cm)
(b) [….] (l. 14 cm, w. 2.5 cm)
(c) [….] (dimensions for cartouche not published)
Notes: Qualitative chemical analysis shows the presence of Cu, Sb, Ag, Bi, and traces of Ni.

38.5) Lead Ingot LLGS 5; MEB inv. D 64.167.1
Type: D2c
Metrics: l. 44 cm, w. 8 cm, h. 9.5 cm; back l. 40 cm; m: 24 kg
Mold Mark(s):
(a) [….] (l. 6 cm, w. 2-2.5 cm)
(b) [….] (l. 13.5 cm, w. 2-2.5 cm)
(c) [….] (l. 6 cm, w. 2-2.5 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Ag, Bi, and traces of Ni.

38.6) Lead Ingot LLGS 6; MEB inv. D 64.165.1
Type: D2c
Metrics: l. 44 cm, w. 8.5 cm, h. 9.5 cm; back l. 41 cm; m: 24 kg
Mold Mark(s):
(a) [….] (l. 9 cm, w. 2.5 cm)
(b) [….] (l. 9 cm, w. 2.5 cm)
(c) [….] (l. 9 cm, w. 2.5 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Sb, Ag, Bi, and traces of Ni.

38.7) Lead Ingot LLGS 7; MEB inv. D 64.169.1
Type: D2c

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[700] Craddock 1995, 211.

Metrics: l. 45 cm, w. 8.5 cm, h. 9.5 cm; back l. 40.5 cm; m: 26 kg
Mold Mark(s):
(a) [….] (l. 8.5 cm, w. 2-2.5 cm)
(b) [….] (l. 8.5 cm, w. 2-2.5 cm)
(c) [….] (l. 8.5 cm, w. 2-2.5 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Sb, Ag, Bi, and traces of Ni.

38.8) Lead Ingot LLGS 8; MDR inv. C 140
Type: D2c
Metrics: l. 45.5 cm, w. 9 cm, h. 8.8 cm; back l. 42 cm; m: 23.5 kg
Mold Mark(s):
(a) [….] (l. 10.8 cm, w. 2 cm)
(b) [….] (l. 13.5 cm, w. 2 cm)
(c) [….] (l. 8.8 cm, w. 2 cm)
Notes: Qualitative chemical analysis shows the presence of Cu, Ag, Bi, and traces of Sn, Ni and Fe.

38.9) Lead Ingot LLGS 9
Type: D2c
Metrics: approximately the same size and mass as the rest of the ingots in this group
Mold Mark(s): three cartouches present, only one partially legible (tentative):
a) *SOC…*
Notes: Ingot is now lost; data published in *LLGS* is based on Benoit 1960.

Roman Empire

39) Comacchio

Alternate names: Valle Ponti
Region: Emilia Romagna (IT) *BA* 40:D3
Date: late 1st c. B.C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 102
Discussion: This well-preserved wreck from the Po River at Ravenna, near the northern Adriatic coast of Italy, was excavated in 1981. It carried a heterogeneous cargo of amphorae from a variety of Greek cities, lead ingots, boxwood logs, gravel (possibly as ballast), a variety of coarsewares, lamps, *terra sigillata* tablewares, some utilitarian bronze items, and several rare temple models of lead. The lead totaled just over 3 tons, with ingots ranging from 19 to 45 kg. The ingots were piled up in the central section along the eastern side, although they may have shifted to this position during the sinking. These ingots were relatively rudimentary in form and lacked a consistent weight standard, unlike many ingots found from this period. Several of the secondary stamps identified may be monograms of well-known producers from earlier in the century. Why these should be so different from other Republican output is not known. They may be indicative of a period of disruption to normal mining operations or they might have been produced in haste to fill an urgent need.

Overall, Berti identified five groups of ingots based on their shape and size.[701] I have consolidated them here to fit in with the larger typology, but Berti's groups are indicated in the notes for each entry.[702] Ingots 1-16 and 17-42 (Berti's groups 1 and 2) are elonged but with rounded ends, similar in shape to one of the ingots from Porticello (**9.2**); they have therefore been classed in the rectangular rounded-back category (B1.3), although they also resemble simple sand-cast plano-convex ingots (A4). Ingots 43-55 show signs of having been cast in a wooden mold, with an attempt at a truncopyramidal form, with more distinct straight edges in some cases (where not obscured by concretion); they have therefore been classed as type B1.2. The final two groups, ingots 56-97 and 98-102, are more regular and and have traces of rectangular cartouches on their backs. Many cartouches are heavily deteriorated but

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[701] Domergue 1990, 74. Domergue (1987) also includes a detailed catalog of these ingots, divided into them into four groupings which are quite different from those Berti published. Overall, Berti is preferred to Domergue due to its later publication date, but the latter is sometimes used to supplement data which is unclear in the former.
[702] Identification of types is based primarily on the sketches provided by Berti (1990); no photographs were published, thus it is difficult to assess which irregularities in shape are inherent to the ingot and which related to post-depositional damage.

others appear to have been filled in with lead, perhaps in an attempt to cover up the original mold mark.[703] Since the two groups do not fully conform to either of the truncopyramidal types defined by Domergue, I have also labeled them as B1.2, although it should be noted that they are better formed than the previous group and may represent an early stage of development of the D4 type.[704] For many years the origin of these ingots was a mystery, since they were not as well-formed as most ingots from Spain, they lacked traceable mold marks and their presence in an Adriatic port was unusual. Lead isotope analysis was finally performed in 2005 on 20 ingots, and the results revealed two distinct groupings. Seventeen ingots cluster together and are compatible with ingots from the Cartagena-Mazarrón or Sierra Almagrera regions of southeastern Spain; the second group of three ingots matches ores from Cartagena-Mazarrón. This suggests the cargo was made up of ingots from at least two different mines.

The various stamps (10 in all) will be discussed in detail at their first appearance only. Since several defy easy description, they are all pictured in figure A-2. Overstrikes are noted when they are visible in figures included in Berti 1990. Inventory numbers are from the Museo Archeologico Nazionale di Ferrara (MAF).

References: Berti 1987; Domergue 1987; Berti 1990; Parker 1992a, 443; Domergue et al. 2006 (particularly for interpretation of inscriptions)

39.1) Lead Ingot Berti 1; MAF inv. 57080
Type: B1.3
Metrics: l. 54 cm, w. 12 cm, h. 6.5 cm; m. 38.6 kg
Notes: Partially covered with concretion; no secondary markings visible. Belongs to Berti's group 1, described as rectangular-based with a sub-triangular transverse section.

39.2) Lead ingot Berti 2; MAF inv. 54853
Type: B1.3
Metrics: l. 44 cm, w. 11.2 cm, h. 5.5 cm; m. 20.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and AT in ligature; stamped twice on base)
b) AGRIP (stamped on base)
c) GEME (ME in ligature; stamped twice on base)

Notes: Berti group 1. Inscription (a) appears on 96 ingots, (b) on 92 ingots, and (c) on at least 20 ingots. Several names have been suggested for (a) including *Caecilius* (a name associated with Agrippa by marriage), *Caesius* or *Caedius* (both attested in inscriptions at Carthago Nova); BAT may be an original Iberian name, and *Batia*, *Baticus* and *Batialus* have all been proposed. Inscription (b) is widely accepted as *Agrippa* and likely represents Augustus' son-in-law M. Agrippa who was a patron of Carthago Nova and was known for having his own contingent of lead workers in Rome, which he later willed to the state.[705] As an admiral under Augustus, he may also have acquired lead for the outfitting of ships stationed at the

[703] Such cases are noted in Domergue (1987), but as his numbering system does not correspond to those in Berti (1990), where this detail is not noted, it is very difficult to properly identify each instance. Therefore cartouches that are concreted or filled in with lead will be equally described as "obscured" in the following ingot entries.

[704] Domergue (1987) himself did not incorporate the Valli Ponte ingots into his established typology, prerferring to assign them their own numbering system with a prefix of V.P. I have therefore avoided assigning them Domergue types, though they do closely resemble type D4.

[705] Frontinus *De Aq.* 116.

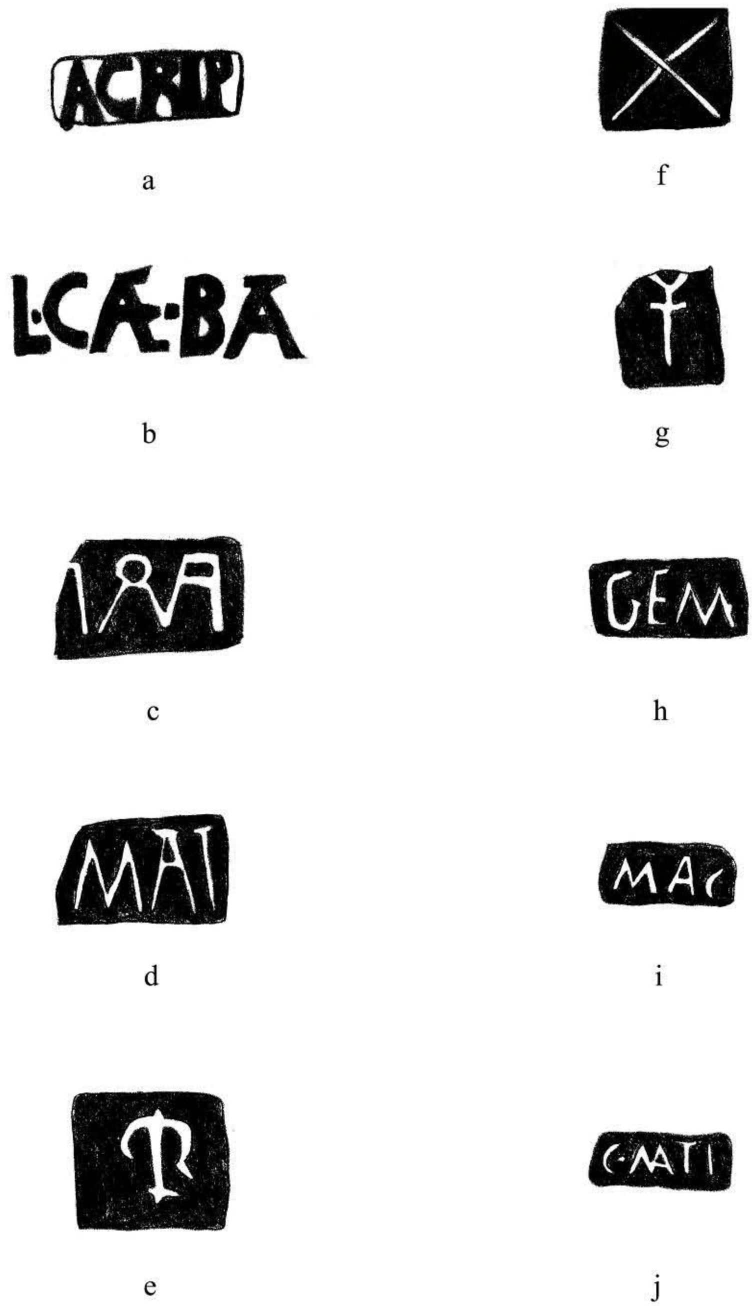

Fig A-2. Stamps found on the ingots from the Comacchio wreck (**39**). After Berti 1990, fig. 12.

newly established naval station of Classis, near Ravenna. Inscription (c) most likely represents a name, but no direct connection to Carthago Nova has been found; Gemellus has been suggested, as has Gemellinus and Gemellianus.

39.3) Lead ingot Berti 3; MAF inv. 54864
Type: B1.3
Metrics: l. 45 cm, w. 13 cm, h. 3.5 cm; m. 19.45 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped on back)
c) C·MATI (MA in ligature; stamped twice on base)
d) MAC (stamped on back)
Notes: Berti group 1. Flat surface curves inward longitudinally. Inscription (c) only occurs on four ingots. It has been restored as *G(aii) Mati*, but the name Matius so far has no known parallels in Carthago Nova. Inscription (d) appears on 11 ingots, and is believed to accompany the name C. MATI as a *cognomen*, though what this name is cannot be determined.

39.4) Lead ingot Berti 4; MAF inv. 54859
Type: B1.3
Metrics: l. 54.5 cm, w. 16 cm, h. 5 cm; m. 31.95 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on back)
c) C·MATI (MA in ligature; stamped twice on base)
d) MAC (stamped on back)
Notes: Berti group 1. One end is more rounded and crushed than the other. For interpretation of (c) and (d), see 39.3.(c) and 39.3(d).

39.5) Lead ingot Berti 5; MAF inv. 57097
Type: B1.3
Metrics: l. 49 cm, w. 16.3 cm, h. 5.5 cm; m. 28.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) PLR (all in ligature; stamped on base)
Notes: Berti group 1. Inscription (b) is a stylized monogram set in a square cartouche that looks somewhat like an anchor, but can be interpreted as a reversed P sharing its vertical stroke with an L and an R (Fig. A.2e). While many names could fit with these initials, Domergue believes the most likely is *Pl(anii) R(ussini)*, a name well-attested in mold marks of the first century B.C.E. (**16**, **17** , **21**, **27**, **30**, and **31**).

39.6) Lead ingot Berti 6; MAF inv. 57129
Type: B1.3
Metrics: l. 53 cm, w. 17 cm,[706] h. 5 cm; m. 33.05 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on back)
c) V (freehand twice on base)[707]
Notes: Berti group 1.

39.7) Lead ingot Berti 7; MAF inv. 57083
Type: B1.3
Metrics: l. 50.5 cm, w. 15.5 cm, h. 6 cm; m. 31.95 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) GEME (stamped on back)
Notes: Berti group 1.

39.8) Lead ingot Berti 8; MAF inv. 57093
Type: B1.3
Metrics: l. 49 cm, w. 14 cm, h. 5.3 cm; m. 29.7 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 1.

[706] Berti appears to have accidentally switched length/width measurements (listed as 1. 17, w. 53).
[707] Inscription (c) not listed in Domergue 1987.

39.9) Lead ingot Berti 9; MAF inv. 54856
Type: B1.3
Metrics: l. 49.5 cm, w. 16 cm, h. 5.5 cm; m. 36.85 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) VTI (all in ligature; stamped twice on back)
Notes: Berti group 1. Inscription (c) is a stylized device originally described by its resemblance to a candle in a holder (Fig. A.2g). It has been interpreted by Domergue as V on top of the vertical stroke of an I and above the crossbar of a T on the same vertical stroke. The name Utius is attested in mold marks on many ingots from the first century BC (18, 21, 22, 23, 26, 27).

39.10) Lead ingot Berti 10; MAF inv. 54860
Type: B1.3
Metrics: l. 45 cm, w. 15.9 cm, h. 6.4 cm; m. 31.55 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) GEME (ME in ligature; stamped on back, incomplete)
d) FVRI (all in ligature; stamped on back)
e) ỊRA (stamped on back)
Notes: Berti group 1. Inscription (d) is essentially an X, sometimes with a closed top and bottom, and enclosed in a small cartouche (Fig. A.2f). Domergue has deciphered this as FVRI, with the F, V, and R all in ligature. This name is attested frequently at Carthago Nova, and is found, in the form Furieis, on an ingot from Pointe de Bonnieu (**35.1**). No interpretation has been offered for inscription (e). It may represent a *tria nomina*, as there are no attested Roman *gentes* beginning with IRA.

39.11) Lead ingot Berti 11; MAF inv. 57081
Type: B1.3
Metrics: l. 47.5 cm, w. 16.5 cm, h. 5.7 cm; m. 37.75 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on back)
c) GEME (ME in ligature; stamped on back)
d) MAC (stamped on back)
e) V (slight crossing of intersecting lines; freehand on base)
Notes: Berti group 1.

39.12) Lead ingot Berti 12; MAF inv. 54870
Type: B1.3
Metrics: l. 46.5 cm, w. 14.5 cm, h. 7 cm; m. 30.55 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) MAT (stamped twice on base)
Notes: Berti group 1. Inscription (c) is interpreted as a shortened form of 39.3(c).

39.13) Lead ingot Berti 13; MAF inv. 54851
Type: B1.3
Metrics: l. 44 cm, w. 15 cm, h. 7.4 cm; m. 31.6 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on base)
c) GEME (ME in ligature; stamped on back)
d) FVRI (stamped on back)
e) IRA (stamped on back)
Notes: Berti group 1.

39.14) Lead ingot Berti 14; MAF inv. 54873
Type: B1.3
Metrics: l. 42 cm, w. 15 cm, h. 7 cm; m. 28.55 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on back)
c) MAC (stamped on back)
Notes: Berti group 1.

39.15) Lead ingot Berti 15; MAF inv. 54854
Type: B1.3
Metrics: l. 46.5 cm, w. 14.3 cm, h. 7.5 cm; m. 33.95 kg
Secondary Markings/Features:

a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped four times on base)
c) MAT (stamped twice on base)
Notes: Berti group 1.

39.16) Lead ingot Berti 16; MAF inv. 54850
Type: B1.3
Metrics: l. 48 cm, w. 17 cm, h. 7.5 cm; m. 36.2 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) GEME (ME in ligature; stamped on back)
d) FVRI (stamped on back)
e) IRA (stamped twice on back, both incomplete)
Notes: Berti group 1.

39.17) Lead ingot Berti 17; MAF inv. 57130
Type: B1.3
Metrics: l. 50 cm, w. 15 cm, h. 6.4 cm; m. 32.85 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base, incomplete)
b) AGRIP (stamped on back)
c) C·MATI (MA in ligature; stamped twice on base, once on back)
Notes: Berti group 2, described as rectangular-based with rounded corners and rounded transverse section.

39.18) Lead ingot Berti 18; MAF inv. 57100
Type: B1.3
Metrics: l. 49 cm, w. 15 cm, h. 6.8 cm; m. 33.25 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) GEME (ME in ligature; stamped on back)
d) FVRI (stamped on back)
Notes: Berti group 2.

39.19) Lead ingot Berti 19; MAF inv. 54863
Type: B1.3
Metrics: l. 43 cm, w. 16.2 cm, h. 6.2 cm; m. 32.3 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) VTI (stamped on back)
Notes: One end is higher and more elongated than the other. Berti group 2.

39.20) Lead ingot Berti 20; MAF inv. 57124
Type: B1.3
Metrics: l. 44 cm, w. 15 cm, h. 7.5 cm; m. 35.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped three times on base)
Notes: Berti group 2.

39.21) Lead ingot Berti 21; MAF inv. 57076
Type: B1.3
Metrics: l. 43 cm, w. 14 cm, h. 6 cm; m. 28.65 kg
Secondary Markings/Features:
a) AGRIP (stamped twice on base)
b) L·CAE·BAT (AE and BA in ligature; stamped on base)
c) FVRI (stamped on base)
Notes: Berti group 2.

39.22) Lead ingot Berti 22; MAF inv. 57061
Type: B1.3
Metrics: l. 43.5 cm, w. 14.5 cm, h. 7.7 cm; m. 30.25 kg
Secondary Markings/Features:
a) GEME (ME in ligature; stamped on base)
b) AGRIP (stamped on back)
Notes: Berti group 2.

39.23) Lead ingot Berti 23; MAF inv. 54865
Type: B1.3
Metrics: l. 47 cm, w. 14.7 cm, h. 8.5 cm; m. 33 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped five times on base)
c) GEME (ME in ligature; stamped on back)
d) FVRI (stamped on back, incomplete)
e) PLR (stamped on back)
Notes: Berti group 2.

39.24) Lead ingot Berti 24; MAF inv. 57095
Type: B1.3

Metrics: l. 46.5 cm, w. 13.5 cm, h. 7.5 cm; m. 29.2 kg
Secondary Markings/Features:
a) AGRIP (stamped twice on base)
Notes: Berti group 2.

39.25) Lead ingot Berti 25; MAF inv. 57128
Type: B1.3
Metrics: l. 47.5 cm, w. 14.7 cm, h. 6.5 cm; m. 31.45 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) C·MATI (MA in ligature; stamped on back)
Notes: Berti group 2.

39.26) Lead ingot Berti 26; MAF inv. 54869
Type: B1.3
Metrics: l. 45 cm, w. 14 cm, h. 7 cm; m. 29.7 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped four times on base)
c) GEME (ME in ligature; stamped on back)
d) FVRI (stamped on back)
e) IRA (stamped on back)
Notes: Berti group 2.

39.27) Lead ingot Berti 27; MAF inv. 54868
Type: B1.3
Metrics: l. 46 cm, w. 16 cm, h. 7 cm; m. 32.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 2.

39.28) Lead ingot Berti 28; MAF inv. 57101
Type: B1.3
Metrics: l. 55 cm, w. 14.8 cm, h. 6 cm; m. 33.85 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on base)
c) FVRI (stamped on back)
d) IRA (stamped on back)
Notes: Traces of freehand mark are visible on the base, but cannot be read clearly. Berti group 2.

39.29) Lead ingot Berti 29; MAF inv. 57125
Type: B1.3
Metrics: l. 48 cm, w. 14.7 cm, h. 6.5 cm; m. 34.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) MAT (stamped twice times on base)
c) AGRIP (stamped twice on back)
Notes: Berti group 2.

39.30) Lead ingot Berti 30; MAF inv. 54857
Type: B1.3
Metrics: l. 44 cm, w. 15.5 cm, h. 7 cm; m. 30.45 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on back)
b) AGRIP (stamped three times on back)
c) GEME (ME in ligature; stamped on base)
Notes: Berti group 2.

39.31) Lead ingot Berti 31; MAF inv. 57084
Type: B1.3
Metrics: l. 46.5 cm, w. 14.2 cm, h. 7.5 cm; m. 37.4 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped four times on base)
Notes: Berti group 2.

39.32) Lead ingot Berti 32; MAF inv. 54852
Type: B1.3
Metrics: l. 43.5 cm, w. 15.5 cm, h. 7.5 cm; m. 31.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped once on base, once on back)
c) GEME (ME in ligature; stamped on back)
d) FVRI (stamped on back)
e) IRA (stamped on back)
Notes: Berti group 2.

39.33) Lead ingot Berti 33; MAF inv. 54862
Type: B1.3
Metrics: l. 45 cm, w. 15 cm, h. 7.5 cm; m. 30.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped five times on base)
c) FVRI (stamped twice on back)
d) GEME (ME in ligature; stamped on back)
e) IRA (stamped twice on back)
Notes: Berti group 2.

39.34) Lead ingot Berti 34; MAF inv. 54855
Type: B1.3
Metrics: l. 43 cm, w. 15.5 cm, h. 7.3 cm; m. 37.7 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on base)
c) GEME (ME in ligature; stamped twice on base)
Notes: Berti group 2.

39.35) Lead ingot Berti 35; MAF inv. 57117
Type: B1.3
Metrics: l. 55.2 cm, w. 13 cm, h. 5.8 cm; m. 29.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on base)
c) PLR (stamped on base)
Notes: Berti group 2.

39.36) Lead ingot Berti 36; MAF inv. 57107
Type: B1.3
Metrics: l. 61 cm, w. 14 cm, h. 5.6 cm; m. 39.0 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
Notes: Berti group 2.

39.37) Lead ingot Berti 37; MAF inv. 57104
Type: B1.3
Metrics: l. 45.5 cm, w. 5? cm,[708] h. 5 cm; m. 29.5 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) GEME (ME in ligature; stamped twice on base)
Notes: Berti group 2.

39.38) Lead ingot Berti 38; MAF inv. 54858
Type: B1.3
Metrics: l. 54 cm, w. 16.5 cm, h. 5 cm; m. 38.3 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on back)
c) GEME (ME in ligature; stamped twice on base)
d) MAC (stamped on back)
Notes: Berti group 2.

39.39) Lead ingot Berti 39; MAF inv. 54861
Type: B1.3
Metrics: l. 44.5 cm, w. 13.8 cm, h. 6 cm; m. 25.05 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped four times on back)
c) MAC (stamped on back)
Notes: Berti group 2.

39.40) Lead ingot Berti 40; MAF inv. 57064
Type: B1.3
Metrics: l. 49.5 cm, w. 14.4 cm, h. 7 cm; m. 32.025 kg
Secondary Markings/Features:

[708] This figure appears to be a typographical error, as no other ingot is less than 9 cm wide. Domergue's 1987 catalog reveals one ingot (#85) which may be the same as Berti's #37. All other dimensions are comparable (l. 45.5, h. 5 cm, m. 30 kg), with the width given as 14.5/17.0/16.8 cm at various points along the length. The only inscription reported by Domergue is (b), but further stamps may have been revealed by cleaning after publication.

a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on back)
Notes: Berti group 2.

39.41) Lead ingot Berti 41; MAF inv. 57126
Type: B1.3
Metrics: l. 46 cm, w. 14.8 cm, h. 7 cm; m. 33.3 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice times on back)
c) MAC (stamped on back)
Notes: Berti group 2.

39.42) Lead ingot Berti 42; MAF inv. 54871
Type: B1.3
Metrics: l. 46.5 cm, w. 11 cm, h. 7 cm; m. 30.3 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice times on back)
Notes: Transverse section follows a much fuller arc than the others of this type. Berti group 2.

39.43) Lead ingot Berti 43; MAF inv. 57065
Type: B1.2
Metrics: l. 43 cm, w. 15 cm, h. 5.8 cm; m. 27.35 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
Notes: Berti group 3, described as rectangular-based with a wide back and truncopyramidal in transverse section.

39.44) Lead ingot Berti 44; MAF inv. 54866
Type: B1.2
Metrics: l. 50 cm, w. 10 cm, h. 6.3 cm; m. 24.5 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on base)
Notes: Berti group 3.

39.45) Lead ingot Berti 45; MAF inv. 54872
Type: B1.2
Metrics: l. 45.5 cm, w. 14 cm, h. 6.4 cm; m. 31.05 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
Notes: Berti group 3.

39.46) Lead ingot Berti 46; MAF inv. 57123
Type: B1.2
Metrics: l. 45.5 cm, w. 12.5 cm, h. 6.8 cm; m. 29.9 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped four times on base, one incomplete)
Notes: Berti group 3.

39.47) Lead ingot Berti 47; MAF inv. 54867
Type: B1.2
Metrics: l. 47.5 cm, w. 14.3 cm, h. 6 cm; m. 33.4 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped four times on base)
Notes: Berti group 3.

39.48) Lead ingot Berti 48; MAF inv. 57062
Type: B1.2
Metrics: l. 46 cm, w. 14.8 cm, h. 7 cm; m. 34.9 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped five times on base)
Notes: One instance of (a) appears to have been struck over one instance of (b). Berti group 3.

39.49) Lead ingot Berti 49; MAF inv. 57127
Type: B1.2
Metrics: l. 48 cm, w. 14.3 cm, h. 6.5 cm; m. 33.3 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three on base)
c) MAC (stamped on base)
Notes: Berti group 3.

39.50) Lead ingot Berti 50; MAF inv. 57113
Type: B1.2
Metrics: l. 45.5 cm, w. 13.3 cm, h. 6 cm; m. 29.9 kg

Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
Notes: Berti group 3.

39.51) Lead ingot Berti 51; MAF inv. 57108
Type: B1.2
Metrics: l. 45 cm, w. 15 cm, h. 10 cm; m. 35.75 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
Notes: Berti group 3.

39.52) Lead ingot Berti 52; MAF inv. 54836
Type: B1.2
Metrics: l. 41 cm, w. 11.5 cm, h. 6.5 cm; m. 24.9 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
c) GEME (ME in ligature; stamped on base)
Notes: Inscription (c) is struck over one instance of (b). Berti group 3.

39.53) Lead ingot Berti 53; MAF inv. 57082
Type: B1.2
Metrics: l. 48 cm, w. 12.5 cm, h. 7.5 cm; m. 39.95 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) MAC (stamped on back)
Notes: A small, deep cavity penetrates the center of the base, although it is difficult to discern if it is a nail hole. Berti group 3.

39.54) Lead ingot Berti 54; MAF inv. 54837
Type: B1.2
Metrics: l. 43 cm, w. 16 cm, h. 8 cm; m. 45.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) GEME (ME in ligature; stamped on base)
Notes: Berti group 3.

39.55) Lead ingot Berti 55; MAF inv. 54833
Type: B1.2
Metrics: l. 45 cm, w. 15 cm, h. 8 cm; m. 40.8 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
c) GEME (ME in ligature; stamped twice on base)
Notes: Traces of what appear to be three freehand letters appear on the base, but cannot be properly read; one instance of (b) appears to have been struck over it. One instance of (b) is struck over (d). Berti group 3.

39.56) Lead ingot Berti 56; MAF inv. 57063
Type: B1.2
Metrics: l. 44 cm, w. 10 cm, h. 9 cm; m. 26.5 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base,)
Notes: Berti group 4, described as rectangular-based, truncopyramidal in transverse section but with relatively rounded lines and corners; they are also characterized by a cartouche centered on the back. Cartouche on back (l. 6.5 cm, w. 4 cm) without visible mark.

39.57) Lead ingot Berti 57; MAF inv. 57078
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 8.5 cm; m. 32 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 11 cm, w. 3.5 cm).

39.58) Lead ingot Berti 58; MAF inv. 57096
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 8.5 cm; m. 31.2 kg
Mold mark(s):
a) *caduceus* (cartouche l. 8 cm, w. 4 cm)
Secondary Markings/Features:

b) L·CAE·BAT (AE and BA in ligature; stamped on base)
c) AGRIP (stamped twice on base)
d) PLR (stamped on base)
Notes: Berti group 4.

39.59) Lead ingot Berti 59; MAF inv. 57094
Type: B1.2
Metrics: l. 46 cm, w. 9.8 cm, h. 7 cm; m. 25.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.60) Lead ingot Berti 60; MAF inv. 57077
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 9.2 cm; m. 29.95 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 9 cm, w. 4 cm).

39.61) Lead ingot Berti 61; MAF inv. 57089
Type: B1.2
Metrics: l. 45 cm, w. 11 cm, h. 8.5 cm; m. 33.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) PLR (stamped on base)
Notes: One instance of (a) is struck over (b). Berti group 4. Cartouche without inscription on back (l. 7 cm, w. 3.5 cm).

39.62) Lead ingot Berti 62; MAF inv. 54842
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 9.5 cm; m. 30.4 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 7.5 cm, w. 4 cm).

39.63) Lead ingot Berti 63; MAF inv. 54841
Type: B1.2
Metrics: l. 45 cm, w. 9.8 cm, h. 7 cm; m. 30.4 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Traces of cartouche on back, too obscured for proper measurements.

39.64) Lead ingot Berti 64; MAF inv. 54838
Type: B1.2
Metrics: l. 56.5 cm, w. 10 cm, h. 9.5 cm; m. 31.85 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped three times on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.65) Lead ingot Berti 65; MAF inv. 54845
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 7.8 cm; m. 27.5 kg
Secondary Markings/Features:
a) AGRIP (stamped on end)
b) PLR (stamped on base)
Notes: Berti group 4. Cartouche on back, but boundaries too obscured for accurate measurement.

39.66) Lead ingot Berti 66; MAF inv. 54846
Type: B1.2
Metrics: l. 44 cm, w. 9.8 cm, h. 7 cm; m. 25 kg
Secondary Markings/Features:
a) AGRIP (stamped twice on base, both incomplete)
b) PLR (stamped on base)
Notes: Berti group 4. Cartouche on back without visible inscription; measurements not given perhaps due to irregularity of boundaries.

39.67) Lead ingot Berti 67; MAF inv. 54849
Type: B1.2
Metrics: l. 45.5 cm, w. 9.8 cm, h. 9.5 cm; m. 29.25 kg

Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 9.3 cm, w. 3.5 cm).

39.68) Lead ingot Berti 68; MAF inv. 54847
Type: B1.2
Metrics: l. 45 cm, w. 9.5 cm, h. 9 cm; m. 27.85 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Traces of cartouche on back but too obscured for measurement.

39.69) Lead ingot Berti 69; MAF inv. 57090
Type: B1.2
Metrics: l. 45.5 cm, w. 9 cm, h. 8.5 cm; m. 29.35 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.70) Lead ingot Berti 70; MAF inv. 57087
Type: B1.2
Metrics: l. 45.5 cm, w. 10 cm, h. 8 cm; m. 22.6 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped four times on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 11 cm, w. 4 cm).

39.71) Lead ingot Berti 71; MAF inv. 54839
Type: B1.2
Metrics: l. 46 cm, w. 10 cm, h. 9 cm; m. 30.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on side)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.72) Lead ingot Berti 72; MAF inv. 54848
Type: B1.2
Metrics: l. 44 cm, w. 9 cm, h. 9 cm; m. 31.3 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 3 cm).

39.73) Lead ingot Berti 73; MAF inv. 54843
Type: B1.2
Metrics: l. 46.5 cm, w. 9.2 cm, h. 8 cm; m. 26.2 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped four times on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche on back to obscured for measurement.

39.74) Lead ingot Berti 74; MAF inv. 57102
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 10 cm; m. 31.25 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche on back too obscured for measurement.

39.75) Lead ingot Berti 75; MAF inv. 57099
Type: B1.2
Metrics: l. 44.5 cm, w. 9.5 cm, h. 8.5 cm; m. 29.55 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche (l. 10.5 cm, w. 4.5 cm) on back with possible traces of caduceus symbol.

39.76) Lead ingot Berti 76; MAF inv. 57110
Type: B1.2
Metrics: l. 45 cm, w. 9.7 cm, h. 7.7 cm; m. 24.75 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.77) Lead ingot Berti 77; MAF inv. 57112
Type: B1.2
Metrics: l. 45 cm, w. 10 cm, h. 8 cm; m. 28.5 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 9.5 cm, w. 4 cm).

39.78) Lead ingot Berti 78; MAF inv. 57111
Type: B1.2
Metrics: l. 45 cm, w. 10.5 cm, h. 9.5 cm; m. 32.4 kg
Mold mark(s):
a) *caduceus* (cartouche l. 9.3 cm, w. 3 cm)
Secondary Markings/Features:
b) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
c) AGRIP (stamped twice on side[709])
d) PLR (stamped on base)
Notes: Berti group 4.

39.79) Lead ingot Berti 79; MAF inv. 57115
Type: B1.2
Metrics: l. 45 cm, w. 9.5 cm, h. 7.6 cm; m. 25.115 kg
Mold mark(s):
a) *caduceus* (cartouche l. 10 cm, w. 3.4 cm)
Secondary Markings/Features:
b) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
c) AGRIP (stamped on base)
d) PLR (stamped on base)
Notes: Berti group 4.

39.80) Lead ingot Berti 80; MAF inv. 57116
Type: B1.2
Metrics: l. 44 cm, w. 10.2 cm, h. 9 cm; m. 29.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on side)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 9 cm, w. 3 cm).

39.81) Lead ingot Berti 81; MAF inv. 57098
Type: B1.2
Metrics: l. 45 cm, w. 9.5 cm, h. 10.5 cm; m. 28.8 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 5 cm).

39.82) Lead ingot Berti 82; MAF inv. 57121
Type: B1.2
Metrics: l. 45 cm, w. 9.5 cm, h. 8.5 cm; m. 29.7 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped twice on base)
Notes: Berti group 4. Cartouche on back too obscured for measurement.

39.83) Lead ingot Berti 83; MAF inv. 57105
Type: B1.2
Metrics: l. 45 cm, w. 10.5 cm, h. 8 cm; m. 31.2 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 3.5 cm).

[709] The catalog in Berti (1990) lists only one (b) stamp but the sketch (Berti 1990, Pl. 11) shows two.

39.84) Lead ingot Berti 84; MAF inv. 57114
Type: B1.2
Metrics: l. 44.3 cm, w. 9.3 cm, h. 8.5 cm; m. 26.7 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.85) Lead ingot Berti 85; MAF inv. 57109
Type: B1.2
Metrics: l. 45 cm, w. 9 cm, h. 8.7 cm; m. 25.55 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base; incomplete)
Notes: Berti group 4. Traces of cartouche present on back but very obscured.

39.86) Lead ingot Berti 86; MAF inv. 57132
Type: B1.2
Metrics: l. 44.5 cm, w. 10.3 cm, h. 8.3 cm; m. 29.9 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped once on back, once on side)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 3.5 cm).

39.87) Lead ingot Berti 87; MAF inv. 57131
Type: B1.2
Metrics: l. 46 cm, w. 10 cm, h. 8 cm; m. 27.2 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 3.5 cm).

39.88) Lead ingot Berti 88; MAF inv. 57088
Type: B1.2
Metrics: l. 44 cm, w. 9 cm, h. 8 cm; m. 22.55 kg
Notes: Ingot heavily concreted, obscuring secondary marks that might be present. Berti group 4. Cartouche without inscription on back (l. 9 cm, w. 4 cm).

39.89) Lead ingot Berti 89; MAF inv. 57122
Type: B1.2
Metrics: l. 45.5 cm, w. 9 cm, h. 9 cm; m. 28.9 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Apparent overstrike of (a) over (b), and (b) over (c). Berti group 4. Cartouche without inscritpion on back (l. 10 cm, w. 3.5 cm).

39.90) Lead ingot Berti 90; MAF inv. 57119
Type: B1.2
Metrics: l. 46.6 cm, w. 10.3 cm, h. 10.8 cm; m. 33.15 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 4 cm).

39.91) Lead ingot Berti 91; MAF inv. 57118
Type: B1.2
Metrics: l. 44 cm, w. 9 cm, h. 8.5 cm; m. 24.7 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on side, both incomplete)
c) PLR (stamped on base)
Notes: Berti group 4. No evidence of cartouche on back, possibly due to heavy concretion.

39.92) Lead ingot Berti 92; MAF inv. 57120
Type: B1.2
Metrics: l. 45.5 cm, w. 10 cm, h. 8.5 cm; m. 28.45 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on base)
c) PLR (stamped on base)

Notes: Berti group 4. Cartouche without inscription on back (l. 9 cm, w. 3.5 cm).

39.93) Lead ingot Berti 93; MAF inv. 57085
Type: B1.2
Metrics: l. 46 cm, w. 10 cm, h. 8.5 cm; m. 32.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on side)
c) PLR(?)[710] (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 10 cm, w. 3 cm).

39.94) Lead ingot Berti 94; MAF inv. 57091
Type: B1.2
Metrics: l. 45.7 cm, w. 10.3 cm, h. 8.5 cm; m. 30.2 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
b) AGRIP (stamped twice on base)
c) PLR(?) (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 7.5 cm, w. 4 cm).

39.95) Lead ingot Berti 95; MAF inv. 54844
Type:
Metrics: l. 45.5 cm, w. 10 cm, h. 8.5 cm; m. 29.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on side[711])
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche without inscription on back (l. 9 cm, w. 3.5 cm).

39.96) Lead ingot Berti 96; MAF inv. 54840
Type: B1.2
Metrics: l. 45 cm, w. 9.5 cm, h. 8 cm; m. 27.4 kg
Mold mark(s):
a) *caduceus* (cartouche l. 9 cm, w. 3.5 cm)
Secondary Markings/Features:
b) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
c) AGRIP (stamped twice on base)
d) PLR (?) (stamped on base)
Notes: Berti group 4.

39.97) Lead ingot Berti 97; MAF inv. 57079
Type: B1.2
Metrics: l. 45 cm, w. 10.5 cm, h. 8 cm; m. 32.1 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped on base)
c) PLR (stamped on base)
Notes: Berti group 4. Cartouche on back too obscured for measurement.

39.98) Lead ingot Berti 98; MAF inv. 57092
Type: B1.2
Metrics: l. 57 cm, w. 9 cm, h. 9.5 cm; m. 36.65 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
Notes: Berti group 5, described as having a truncopyramidal cross section with sharply angled ends and a cartouche on back. Overall, this group has less rounded lines and corners than the previous group. No inscription visible in cartouche (l. 10.5 cm, w. 3 cm).

39.99) Lead ingot Berti 99; MAF inv. 54835
Type: B1.2
Metrics: l. 45.5 cm, w. 9 cm, h. 9.5 cm; m. 35.2 kg
Secondary Markings/Features:
a) L·CAE·BAT (AE and BA in ligature; stamped on base)
b) AGRIP (stamped twice on side)
Notes: Berti group 5. Cartouche without inscription on back (l. 10.5 cm, w. 4 cm).

[710] No sketches of ingots 93 and 94 were provided in Berti (1990); she describes (c) only as “siglo in cartiglio,” which covers several of the various stamps found on the ingots, and the figure is necessary to determine which was meant. The PLR stamp is suggested as most consistent with the other ingots from this group. This is also true for 96(d).
[711] The catalog in Berti (1990) lists only one (a) stamp but the sketch (Pl. 14) shows two.

39.100) Lead ingot Berti 100; MAF inv. 54834
Type: B1.2
Metrics: l. 65 cm, w. 8.5 cm, h. 9.5 cm; m. 36.2 kg
Mold mark(s):
a) *caduceus* (cartouche l. 10 cm, w. 4 cm)
Secondary Markings/Features:
b) L·CAE·BAT (AE and BA in ligature; stamped on base)
c) AGRIP (stamped twice on side)
Notes: Berti group 5.

39.101) Lead ingot Berti 101; MAF inv. 57086
Type: B1.2
Metrics: l. 56.5 cm, w. 9 cm, h. 8.5 cm; m. 34.35 kg
Mold mark(s):
a) *caduceus* (cartouche l. 10 cm, w. 4.9 cm)
Secondary Markings/Features:
b) L·CAE·BAT (AE and BA in ligature; stamped on base)
c) AGRIP (stamped on side)
Notes: Berti group 5.

39.102) Lead ingot Berti 102; MAF inv. 57106
Type: B1.2
Metrics: l. 57 cm, w. 8.8 cm, h. 9.5 cm; m. 34.9 kg
Mold mark(s):
a) *caduceus* (cartouche l. 10 cm, w. 4.5 cm)
Secondary Markings/Features:
b) L·CAE·BAT (AE and BA in ligature; stamped twice on base)
c) AGRIP (stamped on side)
Notes: Berti group 5.

40) Cabrera D

Alternate names: Cabrera A, Cabrera 4, Cabrera 3, Moro Boti[712]
Region: Balearic Islands (ES) BA 27:inset
Date: 1-25 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: "several dozen" (21 published)
Discussion: This wreck was never formally excavated, but its contents were pieced together in the 1970s by tracking down and interviewing many of those who came into possession of artifacts from the site. Over 700 amphoarae were apparently recovered, although only 60 could be studied in detail. The majority of those recorded were Dressel 7. Three bronze helmets were also recovered, which helped to date the site. Other lead objects found include a globular lead vessel and a hollow lead tank, possibly a brazier.[713] Only 21 ingots, out of a reported "several dozen" recovered, have been located and published in detail. Many inscriptions are illegible or partially so due to marine concretions.
References: Veny & Cerda 1972 (VC); Veny 1979; Parker 1992a, 80.

40.1) Lead ingot [714] VC 1
Type: D1a
Metrics: l. 43 cm, w. 10.5 cm., h. 11 cm; m. 30 kg
Mold Mark(s):
a) Ṣ Ḷ Ọ Ṇ (no cartouche dimensions reported)
Secondary Markings/Features:
b) AVSVA (AV and VA in ligature; stamped once on back, once on front face, once on left end, the latter two incomplete)
c) MLICN (stamped on front face)
d) MF *lyre* (MF in ligature; stamped on front face)
Notes: Letters of (a) are very difficult to read. The horizontal stroke of the L in (c) is remarkably short. Inscription (c) and (d) interpreted together as *M(arcus) Lic(inius) / M(arci) F(ilius)*. Inscription (b) appears to represent a second person, possibly a slave or freedman, as it consistently appears on a different face from (c) and (d), which always appear on the same face.

40.2) Lead ingot VC 2
Type: D1a

[712] Supra, note 639.

[713] Cf. Veny 1979, Fig. 5a and Rosen and Galili 2007, Fig 6a.
[714] The first nine ingots were published in Veny and Cerda (1972), with complete inscription details; the additional 12 were published by Veny (1979) with only general details provided about metrics and secondary markings.

Metrics: l. 44 cm, w. 10.5 cm.; back l. 40 cm; m. 30.5 kg
Mold Marks: none, but cartouche present
Secondary Markings/Features:
a) M (incised or punched on back; mlh. 1.5 cm)
b) MLICN (stamped on rear face)
c) MF *lyre* (MF in ligature; stamped on rear face)
d) AVS.. (AV in ligature; stamped twice on left end)
Notes: See 39.1 for interpretation of (b), (c) and (d).

40.3) Lead ingot VC 3
Type: D1a
Metrics: l. 44 cm, w. 10.5 cm., h. 11 cm; back l. 40.5 cm; m. 35 kg
Mold Mark(s):
a) AC…ṆẠỊỊ (cartouche l. 8 cm, w. 3 cm; mlh. 1 cm; second word below first)
Secondary Markings/Features:
b) AVSVA (AV and VA in ligature; stamped twice on rear face)
c) MLICN (stamped on front face)
d) MF *lyre* (MF in ligature; stamped on front face)
Notes: Inscription (a) too incomplete for interpretation. See 39.1 for interpretation of (b), (c) and (d).

40.4) Lead ingot VC 4
Type: D1a
Metrics: l. 43 cm, w. 10 cm., h. 10.5 cm; back l. 39.5; 30.5 kg
Mold Mark(s): none, but cartouche present.
Secondary Markings/Features:
a) AVSVA (AV and VA in ligature; stamped twice on back)
b) MLICN (stamped on rear face)
c) MF *lyre* (MF in ligature; stamped on front face)
Notes: See 39.1 for interpretation of (a), (b) and (c).

40.5) Lead ingot VC 5
Type: D1a
Metrics: l. 44 cm, w. 11 cm., h. 10.5 cm; back l. 40 cm; m. 30 kg
Mold Mark(s): none, but cartouche present.
Secondary Markings/Features:
a) MLICN (stamped on rear face)
b) MF *lyre?* (MF in ligature; stamped on rear face)
c) [AVS]VA (VA in ligature; stamped twice on front face, both incomplete)
Notes: Ingot is heavily concreted. See 39.1 for interpretation of (a), (b) and (c).

40.6) Lead ingot VC 6
Type: D1a
Metrics: l. 43.5 cm, w. 10.5 cm., h. 10.5 cm; back l. 39.5 cm; m. 30 kg
Mold Mark(s): none, but cartouche present
Secondary Markings/Features:
a) MLICN (stamped on rear face)
b) MF *lyre* (MF in ligature; stamped on rear face)
c) [AVS]VA (VA in ligature; stamped on rear face)
Notes: Ingot is heavily concreted. See 39.1 for interpretation of (a), (b), and (c). This is the only case where all three inscriptions appear on the same plane.

40.7) Lead ingot VC 7
Type: D1a
Metrics: l. 43.5 cm, w. 11 cm., h. 11.5 cm; back l. 40 cm; m. 32 kg
Mold Mark(s): none, but cartouche present
Secondary Markings/Features:
a) MLICN (stamped on front face)
b) MF *lyre* (MF in ligature; stamped on front face)
c) AVSVA (AV and VA in ligature; stamped twice on left end; second stamp incomplete)
Notes: Ingot surface is heavily deteriorated. See 39.1 for interpretation of (a), (b), and (c).

40.8) Lead ingot VC 8
Type: D1a
Metrics: l. 44 cm, w. 10 cm., h. 10.5 cm; back l. 40 cm; m. 33.5 kg
Mold Mark(s): none, but cartouche present
Secondary Markings/Features:
a) MLICN (stamped on front face)
b) MF *lyre* (MF in ligature; stamped on front face)
c) AVSVA (AV and VA in ligature; stamped on left end)
Notes: Traces of letters appear in the cartouche but are too deteriorated to read.

See 39.1 for interpretation of (a), (b), and (c).

40.9) Lead ingot VC 9

Type: D1a
Metrics: l. 44.5 cm, w. 11.2 cm., h. 12 cm; back l. 40 cm; m. not given
Mold Mark(s): none, but cartouche present
Secondary Markings/Features:
a) MLICN (stamped on front face)
b) MF *lyre* (MF in ligature; stamped on front face)
c) AVSVA (AV and VA in ligature; stamped on left end)
Notes: Ingot is in a poor state of preservation.

40.10) Lead ingot

Type: D1a
Metrics: l. (av.) 45 cm, w. (av.) 10.5 cm., h. 10 – 11 cm; back l. 39.5 – 40 cm; m. (range for second batch of 12) 33 – 38.2 kg
Mold Mark(s):
a) ANTEROS / EROS (cartouche l. 8 cm, w. 3 cm; mlh. 1 cm; second word below first)
Secondary Markings/Features:
b) MLICN (stamped on front face)
c) MF *lyre* (MF in ligature; stamped on front face)
d) AVSVA (AV and VA in ligature; stamped twice on front face)
Notes: Traces of another inscription are present on the front face, too deteriorated to read, but possibly a second instance of (b). Inscription (a) is unusual for containing two lines of text. No interpretation of the text of (a) has been offered. Inscription (d) taken from Veny and Cerda 1979, Plate 3.

40.11) 2 Lead ingots

Type: D1a
Metrics: l. (av.) 45 cm, w. (av.) 10.5 cm., h. 10 – 11 cm; back l. 39.5 – 40 cm; m. (range for second batch of 12) 33 – 38.2 kg
Mold Mark(s):
a) SOC· VESC (cartouche l. 12 cm, w. 3 cm)
Secondary Markings/Features:
b) MLICN (stamped on front face)
c) MF *lyre* (MF in ligature; stamped on front face)
d) AVSVA (AV and VA in ligature; stamped unknown number of times)
Notes: Traces of an additional stamp are present on the front face, possibly a second instance of (b). Inscription (a) interpreted as *Soc(ietas) Vesc(orum)*. Pliny mentions a town called Vesci or Faventia in Baetica.[715] See 39.1 for inscriptions (b) and (c).

40.12) 2 Lead ingots

Type: D1
Metrics: l. (av.) 45 cm, w. (av.) 10.5 cm., h. 10 – 11 cm; back l. 39.5 – 40 cm; m. (range for second batch of 12) 33 – 38.2 kg
Mold Mark(s):
a) L·IVNII DVO (cartouche l. 12 cm, w. 3 cm)
Secondary Markings/Features:
b) MLICN (stamped on front face)
c) MF *lyre* (MF in ligature; stamped on front face)
d) AVSVA (AV and VA in ligature; stamped unknown number of times)
Notes: Inscription (a) was interpreted by the excavators as indicating two men of the same name (*Lucius Iunius*). See 39.1 for inscriptions (b) and (c).

40.13) 2 Lead ingots

Type: D1a
Metrics: l. (av.) 45 cm, w. (av.) 10.5 cm., h. 10 – 11 cm; back l. 39.5 – 40 cm; m. (range for second batch of 12) 33 – 38.2 kg
Mold Mark(s):
a) T·L·OSCA (cartouche l. 24 cm, w. 3 cm)
Secondary Markings/Features:
b) MLICN (stamped on front face)
c) MF *lyre* (MF in ligature; stamped on front face)
d) AVSVA (AV and VA in ligature; stamped unknown number of times)
Notes: Letters of (a) are very fine with an unusual amount of empty space in the

[715] Pliny *HN* 3.3.5.

cartouche. Traces of several additional secondary marks are visible, but none legible. See 39.1 for inscriptions (b) and (c).

41) Cabrera E

Alternate names: Cabrera 5, Colonia de Sant-Jordi B, Cabrera 1, Cabrera 4[716]
Region: Balearic Islands (ES) *BA* 27:inset
Date: ca. 10 B.C.E. – 25 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found:43+
Discussion: This site, excavated between 1978-9, was heavily looted. The primary cargo appears to have been agricultural products from Baetica, particularly fish products transported in Dressel 7-11 amphorae. At least 43 lead ingots were recovered during the official excavation. Several others, reported separately, may have come from the looted portion of the cargo.[717] The surviving ingots were divided by Colls and colleagues into 10 series based on their mold marks,[718] and several characteristics, such as nail holes, are reported in relation to their series rather than individually. Nail holes are suggested to have resulted from nailing down ingots on river vessels during transport from mining areas in the Sierra Morena to sea ports, and are relatively common on ingots from the first century C.E.[719] Other ingots with nail holes have been found on 36, 45, 48, and 57.

The majority of ingot data is taken from Colls et al. (1986), though Domergue and Liou (1997), having examined the ingots after conservation work was done, published both corrected and new freehand inscriptions.[720] The ingots were weighed against a 100-*libra* standard. Inventory numbers are from the Musée arqueologique de Palma de Majorque (MPM).
References: Veny 1980; Colls et al. 1986; Parker 1992a, 82; Domergue and Liou 1997.

41.1) Lead ingot Colls et al. 1986: 1/1; MPM inv. 12 994

Type: D1b
Metrics: l. 45.4 cm, w. 11.4 cm, h. 11.8-12.4 cm; back l. 40.0; m. 42.19 kg
Mold Mark(s):
a) Q·AELI (cartouche l. 9.8 cm, w. 1.85 cm)
b) SATVLLI (AT in ligature; cartouche l. 10.8 cm, w. 1.95 cm; mlh. 17 mm)
Secondary Markings/Features:
c) L·FANNI (relief stamped twice on front face)
d) Q… (two stamps superimposed on left end)
e) XXXIII (freehand on rear face)
Notes: Two perforations. Inscription (a) and (b) together are interpreted as a single individul, *Q(uinti) Aeli(i) Satulli.* The *gens* Aelia is widely attested in the Roman world, with many traces in the mining regions of Spain, including Castulo, the Guadalquivir valley and Cadiz. Inscription (c) is interpreted as *L(ucii) Fanni(i)*, a name that has also been found stamped on amphorae from Brindisium.[721] This is the most common secondary stamp among the ingots from this site.

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[716] Supra, note 639.
[717] Colls et al. (1986, n. 5) suspect two ingots published by Veny (1980) and two located in private collections likely originated from this site.
[718] The ingot identification number used in Colls et al. (1986) thus has two parts, its series number followed by a unique batch number separated by a slash, e.g. 2/5 (the fifth ingot out of the batch of 43, belonging to series 2, the TANNIBER series).
[719] Domergue 1998, 203-4.
[720] Corrected weight inscriptions taken from Domergue and Liou 1997 are 41.1, 41.5, 41.24 and 41.35; previously unreported weight inscriptions are 41.2, 41.11, 41.17, 41.20, 41.29, 41.30, 41.32, 41.33, 41.37, 41.38, 41.39, 41.41. These figures can also be found in Domergue 1998, Table 2.
[721] Colls et al. (1986, 64) cite *CIL* 9, 6079 (26, 27, 28).

41.2) Lead ingot Colls et al. 1986: 2/2; MPM inv. 12 821
Type: D1a
Metrics: l. 45.6 cm, w. 12.1-12.6 cm, h. 10.3-10.9 cm; back l. 39.5; m. 40.15 kg
Mold Mark(s):
a) TANNIḄER (cartouche l. 11.7 cm, w. 2 cm)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on front face)
c) [XX]III (freehand; location unknown)
Notes: Perforations found on each face, angled left. Inscription (a) is difficult to interpret. Colls and colleauges suggest it is an indigenous Iberian name (meaning "audacious Iberian"), but acknowledge that a Roman-style name such as *T(itus) Ann(ius) Iberus* or *T. Annius Berus* (for *Verus*) is possible. If the first option is correct, it represents a rare case of an indigenous individual succeeding in a mining business dominated by immigrant Romans. On the other hand, if *Annius Verus* is correct, this individual may have had ties to *Annius Verus,* senator for the *Vccbui* and direct ancestor of Marcus Aurelius. Inscription (b) is interpreted as in 41.1(b)

41.3) Lead ingot Colls et al. 1986: 2/3; MPM inv. 12 988
Type: D1a
Metrics: l. 45.5 cm, w. 11.5-11.8 cm, h. 10.6 cm; back l. 39.5 cm; m. 39.31 kg
Mold Mark(s):
a) ṬANNIBẸR (cartouche l. 11.6 cm, w. 2 cm)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on rear face; neither is complete)
Notes: Two perforations, one on the right end, one at an angle in one corner. Inscription (a) is interpreted as in 41.2(a); inscription (b) is interpreted as in 41.1(b).

41.4) Lead ingot Colls et al. 1986: 2/4; MPM inv. 12 984
Type: D1a
Metrics: l. 46.2 cm, w. 12 cm, h. 10.6-10.9 cm; back l. 39.3 cm; m. 41.35 kg
Mold Mark(s):
a) TANNIBER (cartouche l. 11.9 cm, w. 2 cm)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on front face)
c) XXVII (freehand on front face; inverted)
Notes: Two perforations at angles in corners. For (a) see 41.2(a); for (b) see 41.1(b).

41.5) Lead ingot Colls et al. 1986: 2/5; MPM inv. 13 000
Type: D1a
Metrics: l. 45.7 cm, w. 12.5 cm, h. 10.6-10.8 cm; back l. 39.4 cm ; m. 40.85 kg
Mold Mark(s):
a) TANNIḄ.. (cartouche l. 11.8 cm, w. not given)
Secondary Markings/Features:
b) Q·CAECIL (stamped on front face; AE in ligature, CIL in ligature)
c) ..ANNI (relief stamped on rear face)
d) ..METRI (relief stamped on rear face; ME in ligature)
e) XXIIII (freehand on rear face)
Notes: Three perforations are present. Inscription (b) is interpreted as *Q(uinti) Caecil(i)* (or its nominative equivalent). The name *Caecilius* is also attested in mold marks on ingots from this site (41.6-8). *Caecilius* is a widely attested, particularly in central and southern Italy; in Spain instances have been found in Baetica, in such places as Cadiz, Cordoba, Italica, and Écija, where, in the second century C.E., several *Caecili* have been attested as merchants of Baetican oil.[722] There may be a connection between this *Quintus* and the *QQ Caecilii* attested on many oil and garum amphorae in Gaul.[723] Inscription (a) is interpreted as in 41.2(a); inscription (c) is interpreted as in 41.1(b). Inscription (d) has been restored based on 41.34 as *Demetri(i)* and is believed to be the name of a slave or freedman.

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[722] See Colls et al. (1986, n. 72) for detailed citations.
[723] See Colls et al. (1986, n. 130) for detailed citations of these amphorae.

41.6) Lead ingot Colls et al. 1986: 3/6; MPM inv. 12 824

Type: D1a
Metrics: l. 43.3 cm, w. 11 cm, h. 11.8 cm; back l. 39.2 cm; m. 35.9 kg
Mold Mark(s):
a) P CAECILI POPILḶI (cartouche l. 21 cm, w. 3.15 cm; mlh 19.5 mm)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on rear face; one incomplete)
c) Q·POMP (stamped once on rear face, and once (incomplete) on right end)
d) SATVL (stamped on rear face; VL in ligature)
Notes: Perforations in left and right ends. Inscription (a) is interpreted as *P(ublii) Caecili(i) Popilli*. For more on the name Caecilius, see 41.5(b). The *cognomen Popillus* is rare and has not yet been attested in Spain. For (b) see 41.1(b). Incription (c) interpreted as *Q(uinti) Pomp(eii)* or *Pomp(onii)*. Inscription (d) interpreted as *Satul(li)* and has been taken as the *cognomen* accompanying (c).[724] Both *Pompeius* and *Pomponius* are widely attested names, neither with a known connection to the lead industry, so it is difficult to estimate which is more likely indicated in this inscription. It is possible that (d) represents a distinct individual, perhaps the person in 41.1(a) or a relative of his.

41.7) Lead ingot Colls et al. 1986: 3/7; MPM inv. 12 818

Type: D1a
Metrics: l. 43.5 cm, w. 11.5 cm, h. 11 cm; back l. 39.2 cm; m. 36.3 kg
Mold Mark(s):
a) P·CAECILI POPILLI (cartouche l. 21.3 cm, w. 2.8 cm)
Secondary Markings/Features:
b) L·FAṆ.. (relief stamped twice on front face)
c) Q·ṆPOMP (stamped once on front face, twice (incomplete) on right end)
d) ṢAṬ.. (stamped on front face)
e) XII (freehand on rear face; inverted)
Notes: Perforations in left and right ends. Inscription (a) interpreted as in 41.6. See 41.6 for information on (a), (c), and (d); for (b) see 41.1(c).

41.8) Lead ingot Colls et al. 1986: 3/8; MPM inv. 12 826

Type: D1a
Metrics: l. 44 cm, w. 11.8 cm, h. 11.4 cm; back l. 39.0 cm; 35.65 kg
Mold Mark(s):
a) P·CAECILI POPILLI (cartouche l. 20.8 cm, w. not given)
Secondary Markings/Features:
b) L·FANṆ. (relief stamped on front face)
c) Q·P̣OṂP̣ (stamped on rear face)
d) SATVL (stamped on rear face; VL in ligature)
Notes: Traces of freehand markings on front face.

41.9) Lead ingot Colls et al. 1986: 4/9; MPM inv. 12 990

Type: D1a
Metrics: l. 45 cm, w. 12.6 cm, h. 9.6 cm; back l. 38.8 cm; m 34.53 kg
Mold Mark(s):
a) L·F̣ḶA·C·POM (cartouche l. 17.7 cm, w. 2.3 cm)
Secondary Markings/Features:
b) Q·CẠ.… (stamped on front face)
Notes: Inscription (a) is intpreted as representing two individuals, *L(ucii) Fla(vii)* or *Fla(minii)*, and *C(aii) Pom(peii)* or *Pom(ponii)*.[725] Inscription (b) is most likely that attested in 41.5(b).

41.10) Lead ingot Colls et al. 1986: 4/10; MPM inv. 12 982

Type: D1a

[724] Colls et al. (1986, 65) suggest that a longer stamp would be less likely to fully imprint on cold metal, so two shorter stamps were used. Some stamps from Sud Lavezzi B (**47**) are also believed to represent a single name rendered in two parts, as well as the imperial stamps from Ses Salines (**56**).

[725] These have been rendered in the genitive as it is more common, but the case is not identifiable from the inscription.

Metrics: l. 45 cm, w. 12.9-12.2 cm, h. 10.7-11 cm; back l. 39.0 cm; m. 36.45 kg
Mold Mark(s):
a) L·FLA·Ç·POM (cartouche l. 18 cm, w. 2.36 cm)
Secondary Markings/Features:
b) Q·CA.… (stamped on front face)
c) VIIII (freehand on rear face; inverted)
Notes: For inscription (a), see 41.9(a). Inscription (b) is most likely that attested in 41.5(b).

41.11) Lead ingot Colls et al. 1986: 4/11; MPM inv. 12 820
Type: D1a
Metrics: l. 45.6 cm, w. 12.6-14 c1 cm, h. 9.6 cm; back l. 39.0; cm; m. 35.33 kg
Mold Mark(s):
a) Ḷ·F̣ḶẠ . POM (cartouche l. 17.8 cm, w. not given)
Secondary Markings/Features:
b) Q·CAECIL (stamped on rear face; AE in ligature, CIL in ligature)
c) [V]III (freehand; location unknown)
Notes: For inscription (a), see 41.9(a). Inscription (b) is most likely that attested in 41.5(b).

41.12) Lead ingot Colls et al. 1986: 4/12; MPM inv. 12 819
Type: D1a
Metrics: l. 45.3, w. 12.4-13.4 cm, h. 10.2-9.4 cm; back l. 39.0 cm; m. 36.86 kg
Mold Mark(s):
a) L·F̣ḶA Ç·P.. (cartouche measurements not given)
Secondary Markings/Features:
b) Q·CAECIL (stamped on rear face; AE in ligature, CIL in ligature)
c) XI (freehand on rear face, inverted)
Notes: For inscription (a), see 41.9(a). For inscription (b), see 41.5(b).

41.13) Lead ingot Colls et al. 1986: 4/13; MPM inv. 12 993
Type: D1a
Metrics: l. 44.5 cm, w. 11.5-13 cm, h. 9.4-9.7 cm; back l. 38.6 cm; m. 32.12 kg
Mold Mark(s):
a) Ḷ·F̣LA·Ç·P̣ỌṂ (cartouche l. 17.4 cm, w. 2.9 cm)
Secondary Markings/Features:
b) Q·CAECIL (stamped on rear face; AE in ligature, CIL in ligature)
Notes: For inscription (a), see 41.9(a). For inscription (b), see 41.5(b).

41.14) Lead ingot Colls et al. 1986: 4/14; MPM inv. 12 986
Type: D1a
Metrics: l. 44.5 cm, w. 12-12.4 cm, h. 9.7 cm; back l. 39.0 cm; m. 32.63 kg
Mold Mark(s):
a) …….. (cartouche l. 17.7 cm, w. not given)
Secondary Markings/Features:
b) Q·CAECIL (stamped on rear face; AE in ligature, CIL in ligature)
Notes: For inscription (b), see 41.5(b)

41.15) Lead ingot Colls et al. 1986: 4/15; MPM inv. 12 996
Type: D1a
Metrics: l. 44.4 cm, w. 11.6-11.9 cm, h. 9-9.8 cm; back l. 39.0 cm; m. 32.36 kg
Mold Mark(s):
a) Ḷ·F̣Ḷ…ỌṂ (cartouche l. 18 cm, w. not given)
Secondary Markings/Features:
b) Q·CAECIL (stamped on rear face; AE in ligature, CIL in ligature)
Notes: Inscription (a) is most likely the same as 41.9(a). For inscription (b), see 41.5(b).

41.16) Lead ingot Colls et al. 1986: 5/16; MPM inv. 12 812
Type: D1a
Metrics: l. 45.3 cm, w. 11-11.5 cm, h. 11.7-12.1 cm; back l. 40.0 cm; m. 40.5 kg
Mold Mark(s):
a) *palm* Q·HATERI GALLI *palm* (cartouche l. 16.5 cm, w. 2 cm)
Secondary Markings/Features:
b) L · FANNI (relief stamped twice on front face, one incomplete)
c) XXV (freehand on front face)
Notes: One perforation in each end. Inscription (a) is interpreted as *Q(uinti) Hateri Galli*. The family name Haterius is not common, but has been attested in Latium and Campania; it is rare in Hispania. The *cognomen* Gallus is widely attested, particularly in Africa and the Iberian Peninsula. For (b), see 41.4(b).

41.17) Lead ingot Colls et al. 1986: 6/17; MPM inv. 12 998

Type: D1a
Metrics: l. 46.2 cm, w. 11 cm, h. 10.8 cm; back l. 38.2 cm; m. 33 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.3 cm, w. 2.3 cm)
Secondary Markings/Features:
b) L·FANṆ. (relief stamped twice on front face, both incomplete)
c) II (freehand; location unknown)
Notes: One perforation in each side, angled toward the left. Inscription (a) is interpreted as *Have Iuli Vernio*. The first word is likely the greeting *Ave*, sometimes spelled with an initial H, with the subsequent name in the vocative. This formula was frequently used in funerary inscriptions, addressed to the deceased. Colls and colleagues suggest this was used in a humorous vein, with the ingot bidding farewell the producer, Julius Vernio, as it begins the journey to market.[726] The *nomen* Iulius is widely attested in the Roman world, while the cognomen Vernio is relatively rare. It is likely that this individual was a freedman. For inscription (b), see 41.1(c). A third inscription, possibly another (b), was present but entirely illegible.

41.18) Lead ingot Colls et al. 1986: 6/18; MPM inv. 12 978

Type: D1a
Metrics: l. 46 cm, w. 10.8-10.4 cm, h. 10.2 cm; back l. 38.6 cm; m. 33 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.2 cm, w. not given)
Secondary Markings/Features:
b) L·FAṆ.. (relief stamped on rear face)
c) ..METRI (relief stamped on rear face, ME in ligature)
d) Q·CAECIL (stamped on rear face, AE in ligature, CIL in ligature)
Notes: One perforation in rear face, angled to the right; one perforation in left end (incomplete). For inscription (a), see 41.17(b); for (b), see 41.4(b); for (c) see 41.5(d); for (d) see 41.5(b).

41.19) Lead ingot Colls et al. 1986: 6/19; MPM inv. 12 810

Type: D1a
Metrics: l. 46.1 cm, w. 11 cm, h. 10.2-10.5 cm; back l. 38.3 cm; m. 33.42 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.2 cm, w. not given)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on rear face, both incomplete)
c) Q·P·S (stamped three times on left end, all incomplete)
Notes: One perforation on each side, angled to the left. For inscription (a), see 41.17(b); for (b), see 41.4(b). Inscription (c) most likely stands for *Quintus Pompeius* (or *Pomponius*) *Satullus*, the same individual attested in 41.6(c)/41.6(d).

41.20) Lead ingot Colls et al. 1986: 6/20; MPM inv. 12 985

Type: D1a
Metrics: l. 45.6 cm, w. 10.6 cm, h. 10.7 cm; back l. 38.7 cm; m. 33.5 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.5 cm, w. not given)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on front face)
c) Q·P·S (stamped twice on left end, both incomplete)
d) II (freehand, location unknown)
Notes: Two perforations on front face. For inscription (a), see 41.17(b); for (b), see 41.1(c); for (c) see 41.19(c).

41.21) Lead ingot Colls et al. 1986: 6/21; MPM inv. 12 814

Type: D1a
Metrics: l. 45.2 cm, w. 10.2-11 cm, h. 10.3-10.7 cm; back l. 38.7 cm; m. 32.65 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.2 cm, w. not given)
Secondary Markings/Features:

[726] Colls et al. 1986, 54.

b) L·FANN. (relief stamped twice on rear face, one incomplete)
c) Q·P·S (stamped three times on right end, all incomplete)
d) II (freehand on rear face)
Notes: Two perforations on the front face. For inscription (a), see 41.17(b); for (b), see 41.1(c); for (c) see 41.19(c).

41.22) Lead ingot Colls et al. 1986: 6/22; MPM inv. 12 979
Type: D1a
Metrics: l. 46.1 cm, w. 10.8-11.1 cm, h. 10.6 cm; back l. 38.3 cm; m. 34.12 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.1 cm, w. not given)
Secondary Markings/Features:
b) L·FANN. (relief stamped twice on rear face, both incomplete)
c) Q·P·S (stamped once on left end and twice on right end, all incomplete)
Notes: One perforation on each end. For inscription (a), see 41.17(b); for (b), see 41.1(c); for (c) see 41.19(c).

41.23) Lead ingot Colls et al. 1986: 6/23; MPM inv. 12 827
Type: D1a
Metrics: l. 45.8 cm, w. 10.4-10.8 cm, h. 10.2-11 cm; back l. 38.8 cm; m. 33.43 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l. 30.2 cm, w. not given)
Secondary Markings/Features:
b) L·FANN. (relief stamped twice on front face, both incomplete)
c) Q·P·S (stamped three times on left end, all incomplete)
Notes: For inscription (a), see 41.17(b); for (b), see 41.1(c); for (c) see 41.19(c).

41.24) Lead ingot Colls et al. 1986: 6/24; MPM inv. 12 817
Type: D1a
Metrics: l. 45.5 cm, w. 10.9-11 cm, h. 10.5 cm; back l. 38.3 cm; m. 32.81 kg
Mold Mark(s):
a) HAVE *rudder* IVLI *palm* VERNIO (cartouche l.29.8 cm, w. not given)
Secondary Markings/Features:
b) L·FANṆỊ (relief stamped twice on front face, one incomplete)
c) Q·P·S (stamped twice on right end, both incomplete)
d) II (freehand on front face)
Notes: Two perforations on rear face. For inscription (a), see 41.17(b); for (b), see 41.1(c); for (c) see 41.19(c).

41.25) Lead ingot Colls et al. 1986: 7/25; MPM inv. 12 999
Type: D1a
Metrics: l. 46 cm, w. 11.6 cm, h. 11.6-12 cm; back l. 39.2 cm; m. 38.92 kg
Mold Mark(s):
a) PLVMB · *dolphin* C Ạ Ị (cartouche l. 24.7 cm, w. 1.95 cm)
Secondary Markings/Features:
b) L·FANṆỊ (relief stamped twice on front face, both incomplete)
Notes: Inscription (a) was likely intended to represent the name of the mine or mining region from which the *plumb(um)* originated, but the second word is too illegible to be reliably interpreted. For (b) see, 41.1(c).

41.26) Lead ingot Colls et al. 1986: 8/26; MPM inv. 12 997
Type: D1a
Metrics: l. 44.8 cm, w. 12.2 cm, h. 10.8 cm; back l. 40.0 cm; m. 38 kg
Mold Mark(s):
a) PPOSTVMI·RVFI (cartouche l. 18.8 cm, w. 2.7 cm)
Secondary Markings/Features:
b) Q·CAẸ… (stamped on rear face)
Notes: Inscription (a) interpreted as *P(ublii) Postumi(i) Rufi.* The *nomen* Postumius is well attested in Campania, although rare in sounthern Spain. An individual with this same name has been attested in Latium at Atina.[727] For inscription (b), see 41.5(b).

41.27) Lead ingot Colls et al. 1986: 8/27; MPM inv. 12 825
Type: D1a
Metrics: l. 44.6 cm, w. 12.3 cm, h. 11.1 cm; back l. 40.2 cm; m. 39.5 kg
Mold Mark(s):

[727] Colls et al. (1986, 55), citing *CIL* X, 5079.

a) PPOSTVMI·RVFI (cartouche l. 19.6 cm, w. 2.5 cm)
Secondary Markings/Features:
b) L·FANṆ. (relief stamped on rear face)
c) XXI (freehand on front face, inverted)
Notes: For inscription (a), see 41.26(a); for (b), see 41.1(c).

41.28) Lead ingot Colls et al. 1986: 8/28; MPM inv. 12 811
Type: D1a
Metrics: l. 44.5 cm, w. 12.4-12.6 cm, h. 10.6 cm; back l. 40.0; m. 40.45 kg
Mold Mark(s):
a) PPOSTVMI·RVFI (cartouche l. 18.8 cm, w. not given)
Secondary Markings/Features:
b) Ḷ·FANNI (relief stamped twice on front face)
c) XXV (freehand on front face, inverted)
Notes: For inscription (a), see 41.26(a); for (b) see 41.1(c).

41.29) Lead ingot Colls et al. 1986: 8/29; MPM inv. 12 809
Type: D1a
Metrics: l. 44.8 cm, w. 12.2-12.8 cm, h. 10.6 cm; back l. 39.8 cm; m. 39.5 kg
Mold Mark(s):
a) PPOSTVMI·RVFI (cartouche l. 18.7 cm, w. 2.5 cm)
Secondary Markings/Features:
b) L·FAN.. (relief stamped on rear face)
c) XXI (freehand; location unknown)
Notes: Traces of freehand markings on rear face but not enough to interpret. For inscription (a), see 41.26(a); for (b) see 41.1(c).

41.30) Lead ingot Colls et al. 1986: 8/30; MPM inv. 12 828
Type: D1a
Metrics: l. 44.7 cm, w. 12-13 cm, h. 10.4 cm; back l. 39.8 cm; m. 40.15 kg
Mold Mark(s):
a) PPOSTVMI·RVFI (cartouche l. 18.9 cm, w. 2.5 cm)
Secondary Markings/Features:
b) Q·CAẸC.. (stamped on rear face, AE in ligature)
c) XXII (freehand; location unknown)
Notes: Traces of freehand markings on rear face but not enough to interpret. For inscription (a), see 41.26(a); for (b) see 41.5(b).

41.31) Lead ingot Colls et al. 1986: 8/31; MPM inv. 12 815
Type: D1a
Metrics: l. 44.7 cm, w. 11.5-13 cm, h. 10.3-11.1 cm; back l. 39.5 cm; m. 39.6 kg
Mold Mark(s):
a) PPOSTVMI·RVFI (cartouche l. 18.5 cm, w. not given)
Secondary Markings/Features:
b) L·FANNI (relief stamped on front face)
c) XX (freehand on front face)
Notes: For inscription (a), see 41.26(a); for (b) see 41.1(c).

41.32) Lead ingot Colls et al. 1986: 8/32; MPM inv. 12 822
Type: D1a
Metrics: l. 44.8 cm, w. 11.8-12.7 cm, h. 11 cm; back l. 39.8 cm; m. 38.5 kg
Mold Mark(s):
a) P̣POṢTṾṂI·RVFI (cartouche l. 18.7 cm, w. 2.5 cm)
Secondary Markings/Features:
b) L·FANNI (relief stamped twice on front face, both incomplete)
c) XIIX (freehand; location unknown)
Notes: For inscription (a), see 41.26(a); for (b) see 41.1(c).

41.33) Lead ingot Colls et al. 1986: 8/33; MPM inv. 12 987
Type: D1a
Metrics: l. 44.8 cm, w. 12-12.8 cm, h. 10.8-11 cm; back l. 40.2 cm; m. 38 kg
Mold Mark(s):
a) PPOSTVMI·RVFI (cartouche l. 18.9 cm, w. not given)
Secondary Markings/Features:
b) Q·C….. (stamped on rear face)
c) ḌẸṂ…. (relief stamped on right end)
d) XVI (freehand; location unknown)
Notes: Remnants of additional stamp on right end cannot be read. For inscription (a), see 41.26(a); for (b) see 41.5(b); for (c), see 41.5(d).

41.34) Lead ingot Colls et al. 1986: 8/34; MPM inv. 12 823
Type: D1a

<u>Metrics</u>: l. 44.5 cm, w. 12 cm, h. 10.6 cm; back l. 39.2 cm; m. 39.38 kg
<u>Mold Mark(s)</u>:
a) P̣P̣Q̣ṢṬṾṂ [.] ṚṾF̣Ị (cartouche l. 19.0 cm, w. not given)
<u>Secondary Markings/Features</u>:
b) Q·CAE… (stamped on rear face, AE in ligature)
<u>Notes</u>: For inscription (a), see 41.26(a); for (b) see 41.5(b).

41.35) Lead ingot Colls et al. 1986: 9/35; MPM inv. 12 981
<u>Type</u>: D1a
<u>Metrics</u>: l. 45.5 cm, w. 10.8-11.2 cm, h. 11.8 cm; back l. 39.8 cm; m. 40.18 kg
<u>Mold Mark(s)</u>:
a) Ṃ·ṾẠLERI· *palm* ·AḄḶON *dolium* (cartouche l. 26.0 cm, w. 2.0 cm)
<u>Secondary Markings/Features</u>:
b) L·FANṆ. (relief stamped on front face)
c) XXIII S (freehand on front face)
<u>Notes</u>: Perforation on front face and one corner; traces of an additional stamp on front face cannot be read. Inscription (a) is interpreted as *M(arci) Valeri(i) Ablon(ii)* or *Ablon(ni)*. The *nomen* Valerius was common in Hispania, particularly in the mining regions of the Sierra Morena. The *cognomen* Ablo is rare, and reconstruction is based on examples from the northwest of the Iberian peninsula and is most likely Celtic in origin. An ingot bearing this same inscription was found on the Sud Perduto B wreck (45.33), which also had an ingot from another Valeri (45.43). For inscription (b), see 41.1(c).

41.36) Lead ingot Colls et al. 1986: 9/36; MPM inv. 12 983
<u>Type</u>: D1a
<u>Metrics</u>: l. 45.1 cm, w. 11-11.2 cm, h. 11.8 cm; back l. 39.8 cm; m. 38.84 kg
<u>Mold Mark(s)</u>:
a) Ṃ·ṾẠḶẸṚỊ· *palm* ·A[.]ḶON *dolium* (cartouche l. 25.7 cm, w. 1.9 cm)
<u>Notes</u>: Three perforations, one on each face and in one corner. All traces of secondary marks were obscured by concretions. For inscription (a), see 41.35(a); for (b), see 41.1(c).

41.37) Lead ingot Colls et al. 1986: 10/37; MPM inv. 12 816
<u>Type</u>: D1a
<u>Metrics</u>: l. 46 cm, w. 10.6-10.7 cm, h. 11.6 cm; back l. 40.3 cm; m. 37.4 kg
<u>Mold Mark(s)</u>:
a) …… Ḷ F̣ ṚṾ.. (cartouche l. 26.2 cm, w. not given)
<u>Secondary Markings/Features</u>:
b) GI·N. (stamped twice on right end)
c) X[II]II (freehand; location unknown)
<u>Notes</u>: Based on comparisions with other ingots in this series, inscription (a) can only be partially interpreted, as …*us L(ucii) f(ilius) Rufus*. There is enough room to the left of the inscription for this to represent P. Postumus Rufus, seen in ingots 41.26-34, but it could also indicate an entirely different individual. Inscription (b) is too short and badly preserved to interpret, although the G may stand for Gaius, followed by the first letter of a *nomen* (I), and the first two letters of a *cognomen* (NI).

41.38) Lead ingot Colls et al. 1986: 10/38; MPM inv. 12 995
<u>Type</u>: D1a
<u>Metrics</u>: l. 46.5 cm, w. 10.7-11.2 cm, h. 11.4-11.8 cm; back l. 40.4 cm; m. 37.95 kg
<u>Mold Mark(s)</u>:
a) …..ṾṢ Ḷ F̣ ṚṾF̣ṾṢ (cartouche l. 26.0 cm, w. not given)
<u>Secondary Markings/Features</u>:
b) GI·N. (stamped twice on right end)
c) X[V]II (freehand; location unkown)
<u>Notes</u>: For inscription (a), see 41.37(a); for (b) see 41.37(b).

41.39) Lead ingot Colls et al. 1986: 10/39; MPM inv. 12 980
<u>Type</u>: D1a
<u>Metrics</u>: l. 45.8 cm, w. 10.8 cm, h. 10.9 cm; back l. 40.4 cm; m. 38.75 kg
<u>Mold Mark(s)</u>:
a) …… Ṣ·Ḷ·F̣ RVF̣ṾṢ (cartouche l. 26.2 cm, w. not given)
<u>Secondary Markings/Features</u>:
b) GI·Ṇ. (stamped on left end)
c) XV[III] (freehand; location unknown)
<u>Notes</u>: For inscription (a), see 41.37(a); for (b) see 41.37(b).

41.40) Lead ingot Colls et al. 1986: 10/40; MPM inv. 12 813
Type: D1a
Metrics: l. 46.5 cm,w. 10.8-11 cm, h. 11.4 cm; back l. 40.5 cm; m. 38.7 kg
Mold Mark(s):
a) ..... ṾS·L·F·RVF̣ṾṢ (cartouche l. 26.2 cm, w. 2.1 cm)
Secondary Markings/Features:
b) G̣I·Ṇ. (stamped on right end)
c) XVII (freehand twice on front face, one badly made)
Notes: For inscription (a), see 41.37(a); for (b) see 41.37(b).

41.41) Lead ingot Colls et al. 1986: 10/41; MPM inv. 12 992
Type: D1a
Metrics: l. 46.2 cm, w. 11 cm, h. 11.1-11.5 cm; back l. 40.2 cm; m. 37.89 kg
Mold Mark(s):
a) ..... VS·L·F·RṾF̣ṾṢ (cartouche l. 26.2 cm, w. not given)
Secondary Markings/Features:
b) XIIII (freehand; location unknown)
Notes: Traces of freehand markings visible on front face. No traces of secondary stamps apparent. For inscription (a), see 41.37(a).

41.42) Lead ingot Colls et al. 1986: 10/42; MPM inv. 12 991
Type: D1a
Metrics: l. 46 cm, w. 10.5-10.9 cm, h. 11.8 cm; back l. 40.5 cm; m. 38.675 kg
Mold Mark(s):
a) ..... ṾṢ·Ḷ·F·RṾF̣ṾṢ (cartouche l. 26.2 cm, w. not given)
Notes: No traces of any secondary markings visible. For inscription (a), see 41.37(a).

41.43) Lead ingot Colls et al. 1986: 10/43; MPM inv. 12 989
Type: D1a
Metrics: l. 46 cm, w. 10.5-11 cm, h. 11-11.4 cm; back l. 40.9 cm; m. 36.5 kg
Mold Mark(s):
a) .... Ṛ…. (cartouche l. 26.5 cm, w. not given)
Secondary Markings/Features:
b) GI·NI [stamped once (complete) on rear face, and twice (incomplete) on left end]
Notes: Based on similarities with the rest of the series, inscription (a) can most likely be restored as 41.37(a); for (b), see 41.37(b).

42) Cadiz D
Alternate names: Pecio del lingote
Region: Andalucía (ES) *BA* 26:D5
Date: late 1st c. B.C.E to early 1st c. C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 1
Discussion: This site, discovered in the mid-1970s during a systematic survey of Cadiz Harbor, consisted of a number of amphora fragments along with one lead ingot. Not enough context remains to know whether this was a complete wreck or simply loss of cargo. At only 10-12 m. depth, it is possible salvage took place in ancient times, or possibly modern looting. If the amphorae represent cargo, it would appear to have been one of mixed agricultural products with a possible lead component. Inventory number is from Museo Provincial de Cadíz (MPC).
References: Vallespin 1985, 63-4; Parker 1992a, 84

42.1) Lead ingot MPC inv. A/23/74
Type: D1/2
Metrics: l. 58 cm, w. 8 cm, h. 8; m. not given
Mold Mark(s): none
Secondary Markings/Features: none
Notes: The excavator notes that despite the ingot's poor state of preservation it is clear that there were no marks or stamps originally on the ingot, which is unusual for this time period. She describes the shape as having a trapezoidal (longitudinal) cross section, but intermediate between the semi-cylindrical D1 ingots and the truncopyramidal D4 ingots. However, no sketch was published.

43) Cartagena A
Region: Murcia (ES) *BA* 27:E4
Date: 50 B.C.E. –50 C.E.
Cultural Affiliation: Roman

Number of Lead Ingots Found: 30-50?[728]
Discussion: A collection of ingots was discovered during the dredging of Cartagena harbor in 1878. Due to the early date of discovery, no contextual data was recorded. According to Beltrán, 30 ingots were discovered together, most of which were melted down and used in the harbor works, and the remaining few were distributed to various museums and collections.[729] Due to the difficulty in tracing specific ingots back to this site, only two specific ingots are included in this catalog,[730] the rest being grouped together based on information from Beltrán.[731] Several of the surviving ingots were subjected to lead isotope testing and were consistent with samples from the Sierra de Cartagena region.[732]
References: Beltrán 1947; Domergue 1966; Parker 1992a, 129.

43.1) Lead ingot Domergue 1966: 11
Type: D1a?
Metrics: (l. 46.9 cm, w. 10 cm, 8.3 cm ; back l. 44.4 cm; mlh. 1.5 cm; m. 34 kg)
Mold Mark(s):
a) P·NONAE·P·F·NVC (cartouche l. 14 cm, w. 2 cm)
Notes: Inscription (a) interpreted as *P(ublii) Nonae P(ublii) f(ilii) Nuc(erini)*. The restoration *Nucerinus* was selected due to its relative frequency in ancient records, but other options include *Nucula* and *Nucerius*. The *cognomen Nonae* is believed to be of Etruscan origin.

43.2) Lead ingot Domergue 1966: 31
Type: D4
Metrics:
Mold Mark(s):
a)
Notes: Possibly intrusive.

43.3) Ca. 30 lead ingots
Type: D1 and D2 or 4
Metrics: l. 45-51 cm, w. 10 cm; m. 32-35 kg
Mold Mark(s):
a) P·NONAE·P·F·NVC (cartouche l. 14 cm, w. 2 cm)
Notes: Inscription (a) interpreted as in 35.1.

44) Cherchel A
Region: Tipaza (DZ) *BA* 30:D3
Date: 25 B.C.E. – 75 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: "several"
Discussion: Recovered in 1847 from one or, possibly, two hulls found in the harbor of Cherchel, in ancient Caesarea Mauretaniae. No other information about cargo was discovered. Only one ingot bore a legible inscription and thus was published in *CIL* but with no metrics.
References: Leveau 1984, 48; Parker 1992a, 139; *CIL* 8, 10484.1.

44.1) Lead ingot
Type: unknown, possibly D1a?
Metrics: not given
Mold Mark(s):
a) Q. VARI HIBERI
Notes: Inscription (a) is interpreted as *Q(unti) Vari(i) Hiberi*. The *nomen* Varius has been attested throughout the Roman Empire, often in a military context. Several *Quinti* have been attested but no

[728] Parker claims to have traced approximately 50 back to the dredging project, but it is not clear how he came to this number. Beltrán organized his material around inscriptions from surviving ingots in museums and private collections, so provenience and quantities of ingots per inscription are not always clear.
[729] Beltrán 1947, 203-4.
[730] Domergue (1966) identified ingot 31 as being from this site, but given its different type (D4), it is possible that it does not originate from the same depositional event.
[731] Beltrán (1947, 203-4) states "[l]a casi totalidad de estos lingotes fué hallada en un dragado realizido en el puerto de Cartagena en 1878" but does not clearly specify which examples can be reliably traced back to that find. I have included the full list of names he provides with the understanding that several may be from other sites.
[732] Trincherini et al. 2009, Table 1.

other Hiberi.[733] The name does not have any clear ties with any mining regions in Spain, although another ingot with this mold mark was found near Carthago Nova.[734]

45) Sud Perduto B

Alternate names: l'épave de Bétique
Region: Straits of Bonifacio (IT) BA 48:D3
Date: 1-15 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 48
Discussion: Excavated between 1986 and 1989, this site revealed a primary cargo of fish products and wine from Baetica contained in Dressel 7 and 9 amphorae. The date was determined by comparing the range of ceramics on board with collections from various Roman sites including Longarina at Ostia and *Rue de la Favorite* at Lyons. The ingots were stacked on top of the mast step in six layers around the mast. They have been grouped by Bernard and Domergue into 10 series based on their mold marks. Perforations from square nails, ca. 1.2-1.3 cm per side, were found in all series except 4, 5, and 7, and suggest the ingots originated in the Sierra Morena (cf. 36, 41, 48, 57). The ingots were weighted against a 100-*libra* standard. Inventory numbers are for the Musée de Sartene (MS).
References: Bernard and Domergue 1991 (B&D); Parker 1992a, 415.

45.1) Lead ingot B&D 1.1; MS inv. 38
Type: D1.1a
Metrics: l. 45 cm, w. 11 cm, h. 11 cm; back l. 41.5 cm; m. 41.8 kg
Mold Mark(s):
a) *palm* C·ASI[..] (cartouche l. 27 cm, w. 2.8 cm)
Secondary Markings/Features:
b) C·CACI (stamped on right end)
c) PHILA[..] (stamped on right end)
Notes: Traces of freehand numerals on front face. One perforation in corner on right end and front face.

45.2) Lead ingot B&D 1.2; MS inv. 43
Type: D1a
Metrics: l. 45.5 cm, w. 11 cm, h. 11 cm; back l. 41.5 cm; m. 43 kg
Mold Mark(s):
a) [...] C·AS[...] (cartouche l. 26.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL GERM (stamped twice on rear face, both incomplete)[735]
c) C·CAC[.] (stamped on left end)
d) PHILARG (stamped on left end)
e) XXXII (freehand on rear face)
Notes: One centered perforation in each end. Stamp (d) was struck over (c).

45.3) Lead ingot B&D 2.1; MS inv. 34
Type: D1a
Metrics: l. 45.5 cm, w. 12, h. 11 cm; back l. 41 cm, m. 42.8 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 29 cm, w. 3 cm)
Secondary Markings/Features:
b) PHILAR[.] (stamped on right end)
c) C·CACI (stamped on right end)
d) XXXII (freehand on front face)
Notes: One perforation in corner of each end; that on right end cuts into the first 'C' of (c).

45.4) Lead ingot B&D 2.2; MS inv. 41
Type: D1a
Metrics: l. 45 cm, w. 11 cm, h. 11 cm; back l. 41 cm; m. 45.2 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:

[733] For example, a Q. Varius Secund[us] was mentioned in an inscription in Ostia (*AE* 1928, 129) another Secundus in Moesia Inferior under Vespasian (*AE* 1957, 307), Q. Varius Marcellus in Asia Minor, a Q. Varius with no cognomen in Pompei (*CIL* 4, 2045) and another, a *marmorarius*, in Liguria (*CIL* 5, 7670).
[734] Diaz Ariño 2008, SP 38.

[735] When the surviving letters of two incomplete stamps combine to form a complete inscription, the full inscription is included; when both are incomplete and do not contain all letters, the longest surviving string of letters has been reproduced.

b) [..]TVRPIL GERM (stamped twice on front face)
c) PHILA[..] (stamped on right end)
d) […]A[..] (stamped on right end)
e) XXX [..?] (freehand on fron face)
Notes: One centered perforation in each end; that on the right cuts into the beginning of (d), which is interpreted as C·CACI.

45.5) Lead ingot B&D 2.3; MS inv. 26
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h 12 cm; back l. 40.5 cm; m. 43.8 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28, w. 3 l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) P.TVPIL[…] (stamped twice on rear face, both incomplete)
c) […]LARG (stamped on left end)
d) C·CACI (stamped on left end)
e) XXXIIII (freehand on front face)
Notes: One centered perforation in each end.

45.6) Lead ingot B&D 2.4; MS inv. 24
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 12 cm; back l. 41 cm; m. 45.2 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) [..]RPIL GERM (stamped twice on rear face)
c) PH[….] (stamped on left end)
d) C·CAC[.] (stamped on left end)
e) XXXIX (freehand on front face)
Notes: One centered perforation in each end, that on the left end destroying the majority of (c).

45.7) Lead ingot B&D 2.5; MS inv. 43
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 11.5 cm; back l. 41 cm; m. 43 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) [..]RPIL (stamped twice on rear face)
c) [....]ARG (stamped on left end)
d) C·C[...] (stamped on left end)
Notes: One perforation in corner of each end; that on the left end cuts through the last three letters of (d).

45.8) Lead ingot B&D 2.6; MS inv. 22
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 11.5 cm; back l. 41 cm; m. 46 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28 cm, w. 3.2 cm)
Secondary Markings/Features:
b) P. TVRPIL GER[.] (stamped twice on rear face, both incomplete)
c) PHILARG[.] (stamped on left end)
d) C·CACI (stamped on left end)
e) XXXXIIc (freehand on rear face)
Notes: The initial C of (d) was struck over the P of (c). The final C of (e) on a smaller scale than the other figures and may not represent a letter at all. One perforation found in a corner of each end.

45.9) Lead ingot B&D 2.7; MS inv. 19
Type: D1a
Metrics: l. 45 cm, w. 12.5 cm, h. 12 cm; back l. 41 cm; m. 45.6 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL GERM (stamped three times on front face, one almost entirely covered by a second)
c) C·CACI (stamped on right end)
d) XXXX (freehand on right end)
Notes: One perforation in each end.

45.10) Lead ingot B&D 2.8; MS inv. 45
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 12 cm; back l. 41 cm; m. 45.2 kg
Mold Mark(s):
a) M·H [..?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P.TVRPIL GER[.] (stamped twice on rear face)
c) PHIL[…] (stamped on right end)
d) C·C[...] (stamped on right end)
Notes: One perforation on in each end.

45.11) Lead ingot B&D 2.9; MS inv. 21
Type: D1a

Metrics: l. 45.5 cm, w. 12.5 cm, h. 11 cm; back l. 41 cm; m. 43.4 kg
Mold Mark(s):
a) M[·]H [..?] (cartouche l. 28.5 cm, w. 3.2 cm)
Secondary Markings/Features:
b) P·TVRPIL GERM (stamped twice front face, once on rear face, all incomplete)
c) […]CI (stamped on right end)
d) PHIL[....] (stamped on right end)
e) XXXII (freehand on rear face)
Notes: One perforation centered in the left end, and one in the right towards one corner.

45.12) Lead ingot B&D 2.10; MS inv. 23
Type: D1a
Metrics: h. 45 cm, w. 12 cm, h. 11 cm; back l. 41 cm; m. 45.2 kg
Mold Mark(s):
a) M[·]H.. ? (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P.TVRPIL GE[..] (stamped twice on front face)
c) PHILAR[.] (stamped on left end)
d) C·C[...] (stamped on left end)
e) XXXIIX (freehand on left end)
Notes: One perforation centered in each end, that in the left having cut off the final G from (c).

45.13) Lead ingot B&D 2.11; MS inv. 8
Type: D1a
Metrics: l. 45 cm, w. 11 cm, h. 11 cm; back l. 40.5 cm; m. 42.4 kg
Mold Mark(s):
a) M[·]H [..?] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL GERM (stamped twice on front face, one incomplete)
c) [….]ARG (stamped on left end)
d) C·CA[..] (stamped on left end)
Notes: Traces of freehand numeric marks on rear face, but too concreted to read. One perforation centered in the right end, and one in the left toward one corner.

45.14) Lead ingot B&D 2.12; MS inv. 9
Type: D1a
Metrics: l. 45 cm, w. 12 cm, h. 11 cm; back l. 41 cm; m. 44.6 kg
Mold Mark(s):
a) M·H [.. ?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL GE[..] (stamped twice on front face)
c) PHIL[…] (stamped on left end)
d) C[·]CA[..] (stamped on left end)
Notes: One perforation in the middle of each end

45.15) Lead ingot B&D 2.13; MS inv. 44
Type: D1a
Metrics: l. 45.5 cm, w. 12.5 cm, h. 12 cm; back l. 40.5 cm; m. 43.8 kg
Mold Mark(s):
a) M[·]H [.. ?] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) [………] GERM (stamped on front face)
c) C·[.]CAC[.] (stamped on left end)
d) [….]ARG (stamped on left end)
e) XXXIV (freehand on rear face)
Notes: One perforation in each end, that on the right toward one corner and cutting into the A and R of (d).

45.16) Lead ingot B&D 2.14; MS inv. 5
Type: D1a
Metrics: l. 45.5 cm, w. 11.5 cm, h. 11.5 cm; back l. 41 cm; m. 44 kg
Mold Mark(s):
a) M[·]H [.. ?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) [..] TVRPIL GERM (stamped twice on rear face)
c) C·C[...] (stamped on left end)
d) PHILA[..] (stamped on left end)
Notes: One perforation in each end, that on the right toward one corner and that on the left in the middle and cutting of the last three letters of (c).

45.17) Lead ingot B&D 2.15; MS inv. 31
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 12 cm; back l. 41 cm; m. 43.6 kg
Mold Mark(s):
a) M[.]H [.. ?] (cartouche l. 28.5 cms, w. 3 cm)
Secondary Markings/Features:
b) PHILARG (stamped on left end)

c) C·CACI (stamped three times on right end, none complete)
Notes: One perforation in each end near corners.

45.18) Lead ingot B&D 2.16; MS inv. 42
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 11.5 cm; back l. 41.5 cm; m. 45.8 kg
Mold Mark(s):
a) M[.]H [.. ?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) [….]RPIL GERM (stamped one front face)
c) P[……] (stamped on right end)
d) C·C[...] (stamped on right end)
Notes: One perforation in middle of each end.

45.19) Lead ingot B&D 2.17; MS inv. 30
Type: D1a
Metrics: l. 45.5 cm, w. 12 cm, h. 12 cm; back l. 41 cm; m. 44.8 kg
Mold Mark(s):
a) M[·]H [.. ?] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) P[.]TVRPIL GER[.] (stamped twice on front face)
c) […..]RG (stamped on left end)
d) […]A[..] (stamped on left end)
Notes: Inscription (d) restored as C·CACI. One centered perforation in right end, two perforations in left end which cut into (d) and pierce the base.

45.20) Lead ingot B&D 2.18; MS inv. 17
Type: D1a
Metrics: l. 46 cm, w. 12 cm, h. 11.5 cm; back l. 40.5 cm; m. 43.6 kg
Mold Mark(s):
a) M [..... ?] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) P. TVRPIL GERM (stamped twice on front face, both incomplete)
c) PH[…..] (stamped on left end)
d) C·C[…] (stamped on left end)
e) X[… ?] (freehand on front face)
Notes: Numeric mark (e) probably continues under concreted area. One perforation in corner of front face, one centered in left end which cuts into (d).

45.21) Lead ingot B&D 2.19; MS inv. 3
Type: D1a
Metrics: l. 45.5 cm, w. 11.5 cm, h. 11.5 cm; back l. 41 cm; m. 44 kg
Mold Mark(s):
a) M [..... ?] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P.TVRPIL GERM (stamped twice on front face, both incomplete)
c) [...]AC[.] (stamped on right end)
d) [….]AR[.] (stamped on right end)
Notes: One centered perforation in each end, that on the right cutting into (c).

45.22) Lead ingot B&D 2.20; MS inv. 6
Type: D1a
Metrics: l. 45 cm, w. 11.5 cm, h. 11.5 cm; back l. 41 cm; m. 45.4 kg
Mold Mark(s):
a) M[.]H [.. ?](cartouche l. 28.5 cm, w. 3.2 cm)
Secondary Markings/Features:
b) P.TVR[…….] (stamped three times on rear face)
c) C·CA[..] (stamped on left end)
d) PHILAR[.] (stamped on left end)
e) XXXX (freehand on front face)
Notes: One perforation in corner of each end, one penetrating the base.

45.23) Lead ingot B&D 2.21; MS inv. 1
Type: D1a
Metrics: l. 45 cm, w. 11.5 cm, h. 11.5 cm; back l. 41 cm; m. 44.6 kg
Mold Mark(s):
a) [.....] (cartouche l. 28.5 cm, w. 3 cm)
Secondary Markings/Features:
b) [….]RPIL GERM (stamped on front face)
c) C·CA[..] (stamped on left end)
d) PHILAR[.] (stamped on left end)
Notes: One centered perforation in each end, that on the left penetrating the base.

45.24) Lead ingot B&D 2.22; MS inv. 11
Type: D1a
Metrics: l. 45 cm, w. 12 cm, h. 12 cm; back l. 41 cm; m. 46 kg
Mold Mark(s):
a) [.....] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:

b) P·TVRPIL GERM (stamped twice on front face, both incomplete)
c) [….]AR[.] (stamped on right end)
d) C·CA[..] (stamped on right end)
e) XXXXI (freehand on front face)
Notes: A small circular arc appears after (e). One centered perforation in each end, that on the right cutting into (c).

45.25) Lead ingot B&D 2.23; MS inv. 13
Type: D1a
Metrics: l. 45 cm, w. 12 cm, h. 12 cm; back l. 41 cm; m. 44.2 kg
Mold Mark(s):
a) [......] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) P.TVRPIL GERM (stamped twice on front face, both incomplete)
c) […]A[..] (stamped on left end)
d) XXXIIX (freehand on front face)
Notes: Inscription (c) restored as C·CACI. Four perforations in all, one in corner of rear face, two centered in left end, one centered in right end.

45.26) Lead ingot B&D 3.1; MS inv. 50
Type: D1b
Metrics: l. 48.5 cm, w. 12.5 cm, h. 11.5 cm; back l. 43.5 cm; m. 47.8 kg
Mold Mark(s):
a) G· VACALIC[..] (cartouche l. 10.5 cm, w. 3 cm)
b) *dolphin* (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:
c) Q·KAMAEC (stamped on front face)
d) L·AGRI (stamped twice on rear face, one incomplete)
e) XXXXVI (freehand on rear face)
Notes: The complete stamp (d) was struck over the first X of (e). One perforation in corner of left end, one centered perforation (and two attempts at perforation) in right end.

45.27) Lead ingot B&D 3.2; MS inv. 29
Type: D1b
Metrics: l. 47.5 cm, w. 12 cm, h. 11.5 cm; back l. 43.5 cm; m. 45.6 kg
Mold Mark(s):
a) G·VACALICI (cartouche l. 11 cm, w. 3 cm)
b) *dolphin* (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:
c) Q·KAMAEC (stamped on front face)
d) L·AGR[.] (stamped twice on front face)
Notes: One perforation centered in right end, one in corner of left end.

45.28) Lead ingot B&D 3.3; MS inv. 37
Type: D1b
Metrics: l. 48 cm, w. 12 cm, h. 11 cm; back l. 43.5 cm; m. 46.2 kg
Mold Mark(s):
a) [..........] (cartouche l. 10.5 cm, w. 3 cm)
b) *dolphin* (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:
c) [….]AEC (stamped on rear face)
d) L·AGRI (stamped on rear face)
Notes: Portions of freehand numeric marks survive but not legible. One centered perforation on each end, that on right penetrating the base.

45.29) Lead ingot B&D 3.4; MS inv. 4
Type: D1b
Metrics: l. 47.5 cm, w. 11.5 cm, h. 11 cm; back l. 43.5 cm; m. 44.8 kg
Mold Mark(s):
a) [.......] (cartouche l. 10.5 cm, w. 3 cm)
b) *dolphin* (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:
c) L·AGRI (stamped twice on front face, both incomplete)
d) Q·KA[….] (stamped on rear face)
Notes: One perforation centered in right end, one in corner of one face, penetrating the base.

45.30) Lead ingot B&D 3.5; MS inv. 2
Type: D1b
Metrics: l. 47 cm, w. 12 cm, h. 11 cm; back l. 44 cm; m. 47 kg
Mold Mark(s):
a) [.......] (cartouche l. 10.5 cm, w. 2.8 cm)
b) *dolphin* (cartouche l. 10.5 cm, w. 2.8 cm)
Secondary Markings/Features:
c) L·AGRI (stamped twic on front face, one incomplete)
Notes: One perforation in corner of each end.

45.31) Lead ingot B&D 4.1; MS inv. 15
Type: D1b
Metrics: l. 45.8 cm, w. 12 cm, h. 11 cm; back l. 41 cm; m. 44.8 kg

Mold Mark(s):
a) [.......] (cartouche l. 9.5 cm, w. 2.8 cm)
b) VACALICI (cartouche l. 10.5 cm, w. 2.8 cm)
Secondary Markings/Features:
c) [….]RPIL GERM (stamped twice on front face)
d) PHILARG (stamped on right end)
e) […]AC[.]

45.32) Lead ingot B&D 5.1; MS inv. 20
Type: D1a
Metrics: l. 45.5 cm, w. 11 cm, h. 11 cm; back l. 41 cm; m. 42.8 kg
Mold Mark(s):
a) L VALERI·SEVERI (cartouche l. 27.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL GE[..] (stamped twice on rear face)
c) […]C[.] (stamped on right end)
Notes: Evidence of freehand numeric marks visible but illegible beneath concretion, although at least one X can be discerned along with several oblique strokes.

45.33) Lead ingot B&D 6.1; MS inv. 12
Type: D1a
Metrics: no dimensions given; m. 43.6 kg
Mold Mark(s):
a) M·VALERI *dolium* ABLONIS (cartouche dimensions not given)
Secondary Markings/Features:
b) P·TVRPIL GERM (stamped twice on front face, one incomplete)
c) C·CA[..] (stamped on left end)
d) […]XII (freehand on rear face)
Notes: One centered perforation in each end. Numeric marks (d) difficult to read due to concretion.

45.34) Lead ingot B&D 7.1; MS inv. 43
Type: D1a
Metrics: l. 45 cm, w. 12 cm, h. 11.5 cm; back l. 41 cm; m. 46.8 kg
Mold Mark(s):
a) *dolphin rudder dolphin* (cartouche l. 25.5 cm, w. 3.2 cm)
Secondary Markings/Features:
b) [.]·TVRPIL GER[.] (stamped twice on rear face)
c) C·CA[..] (stamped on right end)
d) PHILAR[.] (stamped on right end)
Notes: Traces of freehand numeric marks present but illegible.

45.35) Lead ingot B&D 7.2; MS inv. 10
Type: D1a
Metrics: l. 45 cm, w. 11.9 cm, h. 11.5 cm; back l. 40.5 cm; m. 44.8 kg
Mold Mark(s):
a) *dolphin rudder dolphin* (cartouche l. 24.5 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVR[……] (stamped on front face)
c) PHILARG (stamped on right end)
d) [….]CI (stamped on right end)

45.36) Lead ingot B&D 7.3; MS inv. 18
Type: D1a
Metrics: l. 45 cm, w. 11.5 cm, h. 11 cm; back l. 41 cm; m. 45.8 kg
Mold Mark(s):
a) *dolphin rudder dolphin* (cartouche l. 25 cm, w. 3 cm)
Secondary Markings/Features:
b) [.]·TVRPIL GERM (stamped twice on front face)
c) […]ACI (stamped on left end)
d) PHIL[…] (stamped on left end)
e) ~~IIII~~ II (freehand on rear face)
Notes: A small circular arc appears after (e); the crossbar in (e) descends diagonally from top left to bottom right.

45.37) Lead ingot B&D 7.4; MS inv. 7
Type: D1a
Metrics: l. 44.5 cm, w. 11.5 cm, h. 11.5 cm; back l. 41 cm; m. 45.6 kg
Mold Mark(s):
a) *dolphin rudder dolphin* (cartouche l. 25 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL G[…] (stamped twice on front face)
c) PHILA[..] (stamped on right end)
d) C.C[…] (stamped on right end)
e) ~~IIII~~ I
Notes: The crossbar in (e) descends diagonally from top left to bottom right. On the rear face there are two oblique incisions crossed by a horizontal incision; it has not been interpreted as a deliberate numeric mark or symbol.

45.38) Lead ingot B&D 8.1; MS inv. 33

Type: D2b
Metrics: l. 47.5 cm, w. 13 cm, h. 11 cm; back l. 41 cm; m. 48.2 kg
Mold Mark(s):
a) ANT *palm* (cartouche l. 10 cm, w. 3 cm)
b) AN[......] (cartouche l. 10 cm, w. 3 cm)
Secondary Markings/Features:
c) M·ACCI AN[.] (stamped three times on rear face, and once (incomplete) on left end)
d) C[.]CACI (stamped on left end)
e) PHILAR[.] (stamped on left end)
f) XXXXI[..]
Notes: One perforation in corner of each end. Inscription (d) partially covers (e)

45.39) Lead ingot B&D 9.1; MS inv. 25
Type: D2a
Metrics: l. 49 cm, w. 14 cm, h. 12 cm; back l. 41 cm; m. 47 kg
Mold Mark(s):
a) EMPTOR·EME·G·AV[....] (cartouche l. 28 cm, w. 3 cm)
Secondary Markings/Features:
b) P·TVRPIL GERM (stamped twice on rear face, both incomplete)
c) C·CACI (stamped on left end)
d) PHILAR[.] (stamped on left end)
e) XXXXIIIIM (freehand on front face)
Notes: One centered perforation in right end, one in corner of left end. The M in (e) is described as being at midheight after the final I.

45.40) Lead ingot B&D 9.2; MS inv. 32
Type: D2a
Metrics: l. 49 cm, w. 13 cm, h. 11 cm; back l. 41 cm; m. 43.4 kg
Mold Mark(s):
a) EMPTOR·EME·G·AV[....] (cartouche l. 27.5 cm, w. 3.2 cm)
Secondary Markings/Features:
b) C·CACI (stamped on right end)
c) PHILARG (stamped on right end)
d) XXXIII (freehand on front face)
Notes: Perforation in two corners (end or face not reported).

45.41) Lead ingot B&D 9.3; MS inv. 47
Type: D2a
Metrics: l. 48.5 cm, w. 14 cm, h. 11.5 cm; back l. 41 cm; m. 45.6 kg
Mold Mark(s):
a) EMPTOR·EME·G·AV[....] (cartouche l. 27.5 cm, w. 3 cm)
Secondary Markings/Features:
b) [.]CAC[.] (stamped on left end)
c) PHILARG (stamped on left end)
d) XXXX (freehand on front face)
Notes: One perforation in one corner; two in the corners of left end, one of which penetrates through the base and cuts the final I off the end of (b).

45.42) Lead ingot B&D 10.1; MS inv. 16
Type: D2b
Metrics: l. 47.5 cm, w. 14 cm, h. 11 cm; back l. 40 cm; m. 44 kg
Mold Mark(s):
a) EMPTOR (cartouche l. 10 cm, w. 3 cm)
b) SALVE (cartouche l. 10 cm, w. 3 cm)
Secondary Markings/Features:
c) M·ACCI ANT[.] (stamped four times front face, two limited to two letters)
d) XXXVI (freehand on left end)
Notes: Traces of further freehand numerals on front face are not legible. Perforations in two corners, one of which penetrates through the base.

45.43) Lead ingot B&D 10.2; MS inv. 35
Type: D2b
Metrics: l. 47.5 cm, w. 14.3 cm, h. 11 kg; back l. 40.5 cm; m. 43.8 kg
Mold Mark(s):
a) EMPTOR (cartouche l. 10.5 cm, w. 3 cm)
b) SALVE (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:
c) [..]CACI (stamped twice on left end)
d) [….]ARG (stamped on left end)
e) XXXV (freehand on right end)
Notes: Perforations in two corners, one of which penetrates through the base and cuts into the A in (d).

45.44) Lead ingot B&D 10.3; MS inv. 36
Type: D2b
Metrics: l. 48 cm, w. 14 cm, h. 11 cm; back l. 40.5 cm; m. 43.8 kg
Mold Mark(s):
a) EMPTOR· (cartouche l. 10 cm, w. 3 cm)
b) SALVE (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:

c) XXXV (freehand on front face and left end)
Notes: One perforation and two attempts in one corner, a centered perforation and three attempts in right end.

45.45) Lead ingot B&D 10.4; MS inv. 39
Type: D2b
Metrics: l. 47.5 cm, w. 14 cm, h. 11.5 cm; back l. 40.5 cm; m. 43.8 kg
Mold Mark(s):
a) EMPTOR (cartouche l. 10 cm, w. 3 cm)
b) SALVE (cartouche l. 10 cm, w. 3 cm)
Secondary Markings/Features:
c) M·A[……] (stamped twice on front face)
d) PHIL[…] (stamped on left end)
e) XXXV (freehand on right end)
Notes: One centered perforation in right end, one in corner of left end.

45.46) Lead ingot B&D 10.5; MS inv. 40
Type: D2b
Metrics: l. 47.5 cm, w. 13.5 cm, h. 11 cm; back l. 40.5 cm; m. 44.6 kg
Mold Mark(s):
a) EMPTOR (cartouche l. 10 cm, w. 3 cm)
b) SALVE (cartouche l. 10 cm, w. 3 cm)
Secondary Markings/Features:
c) M·ACCI AN[.] (stamped twice on right end)
d) C[.]CACI (stamped on left end)
e) PHILAR[.] (stamped on left end)
f) XXXIIX (freehand on rear face and right end)
Notes: One perforation in corner of one end, one near base in front face 11.5 cm from corner and one attempt closer to end.

45.47) Lead ingot B&D 10.6; MS inv. 46
Type: D2b
Metrics: l. 48 cm, w. 14.5 cm, h. 11 cm; back l. 40 cm; m. 45.6 kg
Mold Mark(s):
a) EMPTOR (cartouche l. 10 cm, w. 3 cm)
b) SALVE (cartouche l. 10.5 cm, w. 3 cm)
Secondary Markings/Features:
c) M·ACCI AN[.] (stamped twice on rear face)
d) C·CACI (stamped on left end)
e) [….]ARG (stamped on left end)
e) XXXX (freehand on front face and right end)
Notes: One perforation in front face, one in corner of right end.

45.48) Lead ingot B&D 10.7; MS inv. 27
Type: D2b
Metrics: l. 47.5 cm, w. 14 cm, h. 11 cm; back l. 40 cm; m. 43.4 kg
Mold Mark(s):
a) EMPTOR (cartouche l. 10 cm, w. 3 cm)
b) SALVE (cartouche l. 10 cm, w. 3 cm)
Secondary Markings/Features:
c) M·ACCI AN[.] (stamped twice in rear face)
d) [..] CACI (stamped on left end)
e) XXXV (freehand on left end)
Notes: One centered perforation in each end, that in the left cutting off the intial letter of (d).

46) Rena Maiore
Region: Straits of Bonifacio (IT) *BA* 48:D3
Date: 1st c. C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 91+
Discussion: These ingots wer discovered as a group in 1997, 50 m offshore of a public beach in 3 m of water. Associated artifacts include four lead containers, small barrels of lead scoria, other material from lead or iron processing, a possible segment of a limestone column, and two iron anchors. No traces of hull were found. The material was very close to shore, suggesting a beached ship that may have been partially salvaged in antiquity, although the dynamic nature of the seabed at this site may have hampered such efforts.

This collection of ingots, with its variety of shapes and decorative elements, is unique among all ancient lead ingot cargoes and poses difficulties for interpretation. Other ingots with image-based mold marks were found on the Sud Perduto B wreck (45.34-37), the Baie de l'Amitié wreck (54) and the undated Punta della Contessa wreck (67), none of which had any two-part mold marks. In addition to the ingots reported below, an unspecified number of A1 ingots (described as bread-shaped) were also found.

The lead containers were cut and crushed, suggesting they were scrap. They bore molded designs and inscriptions. Two

were rectangular and bore the name *Q*(*uintus*) *Pom*[*peius At*]*ticu*[*s a. f*][736] above a chariot. The other two were originally cylindrical and bore the name *C. Iul*(*ius*) [*Primit*]*ius a. f* along with harvesting scenes. These were most likely funerary urns.
References: D'Oriano 1999; Riccardi and Genovese 2002 (R&G).

46.1) 42 Lead ingots
Type: D4
Metrics: m. ca 63-66.5 kg
Mold Mark(s):
a) AVGVSTI·CAESARIS·GERMANICVM (AN in ligature)
Secondary Markings/Features:
b) LVALRVF (stamped on 29 ingots)
c) CHI (stamped on ends of 25 ingots)
d) IMP (on 3 ingots)
e) *unspecified freehand numerals*
Notes: This group of ingots was designated Type G by the excavators. Four of these ingots appear to have been cast in a mold of slightly smaller capacity than the others and bear slightly smaller cartouches, but carry the same mold mark. An additional 20 ingots of this type were noted in situ but not recovered due to rapid silting in of the site.

Inscription (a) is believed to refer to the emperor Augustus, with "*Germanicum*" in the nominative singular, agreeing with the implied noun "*plumbum*."[737] Inscription (b) is interpreted as *L(ucii) Val(erii) Ruf(i)*. Inscription (c) appears to be the abbreviation of a name; the authors propose a Greek name such as Chilon, suggesting a slave or freedman. This individual may have been connected to the weighing of the ingots as his mark, in 13 cases, appears near the numeric inscriptions (e). The weight marks are calculated against a 100 *libra* standard. Inscription (d) is interpreted as *IMP(eratoris).*

46.2) 19 Lead ingots
Type: B1.1
Metrics: smallest: l. 35 cm, w. 16 cm., h. 5.5 cm; m. 26.5 – 272.3 kg (most above 50 kg)
Mold Mark(s): none
Secondary Markings/Features:
a) *unspecified weight marks* (on 17 ingots)
Notes: The ingots are described as most resembling a brick, although the surface of one large face is consistently irregular compared to the smoothness of the other five faces. Each is a different size, suggesting 19 different molds, possibly makeshift holes in the ground, although with enough care to create smooth sides and regular angles. The weight marks (a) in 14 cases appear to indicate the true weight of the ingot, rather than deviation from a standard. The excavators have designated this group as Type P.

46.3) 4 Lead ingots
Type: B1.1
Metrics: not given
Mold Mark(s):
(a) *scene of gladiatorial games* (on back of 1 ingot)
(b) *half a standing lion* (on both ends of 3 ingots)
Secondary Markings/Features:
d) *unspecified freehand Greek letters* (on the ingots described in (b))
Notes: When two of the ingots in (b) are stacked, the images form a complete lion; one ingot has no partner but it was likely in the original shipment. These ingots are also included in the excavator's Type P category.

46.4) 3 Lead ingots
Type: B2.3

[736] Interpretations propsed for "*a.f.*" all suggest the name refers to the maker rather than the owner, and include *a*(*rtifex*) *f*(*ecit*), *a*(*rgentarius*) *f*(*ecit*), or a city beginning with A, similar to inscriptions lead pipes *v.f.* and *l.f.* (*Viennae fecit* and *Lugduni fecit*).
[737] Initial speculation that the emperor Caligula (Gaius Julius Casear Germanicu) was intended is not supported by the grammar, as this would require his full name in the genitive (*Germanici*) not accusative.

Metrics: smallest: diam. 20 cm, m. 8 kg; largest: diam. 40 cm, m. 76.5 kg.
Mold Mark(s): none
Secondary Markings/Features:
a) CCXXXX (freehand on the heaviest ingot)
c) I..KΘ (freehand on the heaviest ingot)
Notes: These ingots are described as being in the shape of a pot (*paiolo*). The excavators have designated this group of ingots as Type M.

46.5) 1 Lead ingot R&G 58
Type: B1.2
Metrics: not given
Mold Mark(s): none
Secondary Markings/Features:
a) PUDENTIS GERM (twice stamped(?) on back)
b) CHI (stamped on the one end)
Notes: The ingot is described as being truncopyramidal but with rounded edges. *Pudentis* in inscription (a) may refer to a person, likely a slave or freedman named Pudens. Inscription (b) is interpreted as in 46.1(c).

47) Sud Lavezzi B
Alternate names: Sud Lavezzi 2
Region: Strait of Bonifacio (IT) *BA* 48:D3
Date: 10-30 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 97 (2 of which were lost during excavation)
Discussion: This vessel carried a heterogeneous cargo of agricultural and metal products from southern Spain. The wreck was heavily looted between its discovery in 1977 and its excavation in 1978-81, so the size of the complete cargo is unknown. The surviving amphorae include Haltern 70, Dressel 20, 8, and 7, and Pompei 7, with approximately 75% carrying fish products, although consignments of oil and wine products may also have been aboard. In addition to the lead ingots (totaling approximately 2.75 tons), 237 copper ingots were also found (4.4 tons), although it is estimated the ship probably carried closer to 300 (5.6 tons).

The lead ingots were arranged in 9 rows along the longitudinal axis of the hull, apparently between stringers - 4 rows to port (47 ingots), 4 to starboard (45 ingots), and 1 along center (5 ingots), although it is possible 2 ingots were overlooked, making a balanced lading plan. Amphora toes were then placed between them. Three lead anchor stocks were found, with molded letters in relief (APPI·[..], AP·SE, AP·ZE), which correspond to names represented in stamps on the lead ingots,[738] suggesting that the ship's owner or captain was also operating as a merchant rather than just a carrier.[739] The ingots were weighed against a 100-*libra* standard. The authors divided the ingots into three groups, based on similarities in size, weight and the appearance of the mold mark; these groups are referenced in the notes for each ingot. Identification numbers are taken from Liou and Domergue 1990 (L&D1); no museum inventory numbers provided.
References: L'Hour and Long 1985, 38-9; Liou and Domergue 1990; Parker 1992, 414.

47.1) Lead ingot L&D1 1
Type: D2a
Metrics: l. 50 cm, w. 14.7 cm, h. 12.2 cm; back l. 41.8 cm; m. 52.9 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.8 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIII (freehand on rear face)
Notes: Inscription (a) is interpreted as the genitive plural of Minucius, a nomen widely attested in the Roman world, but with no particular ties to mining regions. Inscriptions (b) and (c) are interpreted together as *Ap(pi) Iun(i) Zeth(i)*, or its nominative equivalent. This individual

[738] The letters on the anchor stocks are very large (8-11.5 cm) and thick, with irregular lines and poor alignment, suggesting they were drawn freehand directly in the mold with a finger or blunt instrument.
[739] This wreck is the basis for Model 2 of Domergue's (1998, 207) three models of Baetican ingot trade.

was likely also the owner or captain of the ship, as his name was attested on the anchor stocks. He might have had ties, perhaps as a freedman, to Appius Iunius Silanus, who was governor of Hispania Tarraconensis in 41 C.E.[740] L&D Group 1.

47.2) Lead ingot L&D1 2
Type: D2a
Metrics: l. 49 cm, w. 14.5 cm, h. 12.2 cm; back l. 41.5 cm; m. 52.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.9 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXII (freehand on front face)
Notes: L&D Group 1.

47.3) Lead ingot L&D1 3
Type: D2a
Metrics: l. 49.3 cm, w. 14.9 cm, h. 12.6 cm; back l. 41.4 cm; m. 49.55 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.7 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIII (freehand on front face)
Notes: L&D Group 1.

47.4) Lead ingot L&D1 5
Type: D2a
Metrics: l. 49.2 cm, w. 15 cm, h. 12.5 cm; back l. 41.7 cm; m. 52.85 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.7 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on rear face, once on right end, once on left end)
c) ZETH (stamped once on rear face, three times on right end, once on left end)
d) ЖXIII (freehand on front face)
Notes: Not all stamps are complete. L&D Group 1.

47.5) Lead ingot L&D1 6
Type: D2a
Metrics: l. 49.5 cm, w. 15.1 cm, h. 12.1 cm; back l. 41.2 cm; m. 54 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.9 cm, w. 7.5 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXVII (freehand on rear face)
Notes: L&D Group 1.

47.6) Lead ingot L&D1 7
Type: D2a
Metrics: l. 50.5 cm, w. 14.7 cm, h. 12.1 cm; back l. 42.5 cm; m. 53.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.5 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped five times on rear face)
c) ZETH (stamped on rear face)
d) ЖXIIX (freehand on front face)
Notes: Not all secondary stamps are complete. L&D Group 1.

47.7) Lead ingot L&D1 8
Type: D2a
Metrics: l. 50 cm, w. 15 cm, h. 12.5 cm; back l. 41.2 cm; m. 53.35 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.4 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXV (freehand on rear face)
Notes: L&D Group 1.

47.8) Lead ingot L&D1 9
Type: D2a
Metrics: l. 49.3 cm, w. 14.4 cm, h. 12 cm; back l. 42.2 cm; m. 52.1 kg
Mold Mark(s):

[740] Silanus had strong ties to the Claudian family and was recalled from Spain by Claudius to marry his mother-in-law, Domitia Lepida, in 41 C.E. He was accused of plotting against the emperor and killed the following year.

a) MINVCIORVM (cartouche l. 25.5 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXII (freehand on front face)
Notes: Not all secondary stamps are complete. L&D Group 1.

47.9) Lead ingot L&D1 10
Type: D2a
Metrics: l. 49.5 cm, w. 14.2 cm, h. 12.1 cm; back l. 42.1 cm; m. 52.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.6 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. [..]N (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXII (freehand on rear face)
Notes: Not all secondary stamps are complete. L&D Group 1.

47.10) Lead ingot L&D1 13
Type: D2a
Metrics: l. 48.8 cm, w. 14.3 cm, h. 11.4 cm; back l. 41 cm; m. 50.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 26 cm, w. 7.6 cm)
Secondary Markings/Features:
b) […] IVN (stamped on front face)
c) ZE[.]H (stamped on front face)
d) ЖIIX (freehand on front face)
Notes: L&D Group 1.

47.11) Lead ingot L&D1 14
Type: D2a
Metrics: l. 49 cm, w. 13.7 cm, h. 11.6 cm; back l. 41.2 cm; m. 50.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 26.3 cm, w. 7.5 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on front face, once on right end)
c) ZETH (stamped once on front face, once on right end)
d) ЖIX (freehand on rear face)
Notes: Not all stamps are complete. L&D Group 1.

47.12) Lead ingot L&D1 16
Type: D2a
Metrics: l. 50.5 cm, w. 15.4 cm, h. 12 cm; back l. 41.2 cm; m. 51.55 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖIIX (freehand on front face)
Notes: Not all stamps are complete. L&D Group 1.

47.13) Lead ingot L&D1 17
Type: D2a
Metrics: l. 50.5 cm, w. 15 cm, h. 11 cm; back l. 41 cm; m. 52.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.1 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXII (freehand on front face)
Notes: L&D Group 1.

47.14) Lead ingot L&D1 18
Type: D2a
Metrics: l. 50 cm, w. 15.6 cm, h. 12.1 cm; back l. 41.5 cm; m. 53.2 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.4 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIIII (freehand on rear face)
Notes: L&D Group 1.

47.15) Lead ingot L&D1 19
Type: D2a
Metrics: l. 50.5 cm, w. 15.7 cm, h. 11.6 cm; back l. 41.4 cm; m. 51.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped twice on rear face)
d) ЖX (freehand on front face)
Notes: L&D Group 1.

47.16) Lead ingot L&D1 21

Type: D2a
Metrics: l. 48.7 cm, w. 14 – 15.5 cm, h. 12.3 cm; back l. 42 cm; m. 51.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 26.1 cm, w. 7.7 cm)
Secondary Markings/Features:
b) […] IVN (stamped three times on rear face)
c) ZETH (stamped on rear face)
d) ЖXIIII (freehand on front face)
Notes: Not all stamps are complete. L&D Group 1.

47.17) Lead ingot L&D1 22
Type: D2a
Metrics: l. 49.7 cm, w. 14.4 cm, h. 12.3 cm; back l. 41.4 cm; m. 52 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.2 cm, w. 7.8 cm)
Secondary Markings/Features:
b) […] IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖX (freehand on front face)
Notes: Not all stamps are complete L&D Group 1.

47.18) Lead ingot L&D1 24
Type: D2a
Metrics: l. 49.1 – 50.1 cm, w. 14.5 cm, h. 12 cm; back l. 42 cm; m. 53.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.2 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped three times on front face)
c) ZETH (stamped on front face)
d) ЖXV (freehand on rear face)
Notes: L&D Group 1.

47.19) Lead ingot L&D1 25
Type: D2a
Metrics: l. 49.8 cm, w. 15.5 cm, h. 11.8 cm; back l. 41.6 cm; m. 52.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.6 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖIX (freehand on front face)
Notes: L&D Group 1.

47.20) Lead ingot L&D1 26
Type: D2a
Metrics: l. 49.5 cm, w. 15 cm, h. 12 cm; back l. 41.1 cm; m. 52 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) Ж[…] (freehand on rear face)
Notes: L&D Group 1.

47.21) Lead ingot L&D1 28
Type: D2a
Metrics: l. 49.6 cm, w. 14.5 cm, h. 12.8 cm; back l. 41 cm; m. 54.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.2 cm, w. 7.8 cm)
Secondary Markings/Features:
b) […] IVN (stamped on front face)
c) ZETH (stamped on front face)
d) C MET AATIS […?] (stamped on front face)
e) ЖXV (freehand on front face)
Notes: No interpretation has been offered for (d), and it is the only instance of this stamp on ingots from this site. L&D Group 1.

47.22) Lead ingot L&D1 29
Type: D2a
Metrics: l. 50.5 cm, w. 14.2 cm, h. 12.4 cm; back l. 41.6 cm; m. 52.3 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.8 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
Notes: L&D Group 1.

47.23) Lead ingot L&D1 30
Type: D2a
Metrics: l. 49 cm, w. 14.5 cm, h. 12.3 cm; back l. 41.6 cm; m. 52 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.6 cm, w. 7.7 cm)
Secondary Markings/Features:

b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖX (stamped on rear face)
Notes: L&D Group 1.

47.24) Lead ingot L&D1 31
Type: D2a
Metrics: l. 49.2 – 50 cm, w. 14.5 cm, h. 11.4 cm; back l. 41.6 cm; m. 51.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.9 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
Notes: L&D Group 1.

47.25) Lead ingot L&D1 32
Type: D2a
Metrics: l. 49 cm, w. 14.6 cm, h. 11.5 cm; back l. 41 cm; m. 50.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.5 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖV (freehand on front face)
Notes: L&D Group 1.

47.26) Lead ingot L&D1 33
Type: D2a
Metrics: l. 49.2 cm, w. 14.5 cm, h. 11.7 cm; back l. 41.8 cm; m. 53 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.8 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. IVN (stamped once on rear face and once on left end)
c) ZETH (stamped twice on rear face)
d) ЖXIIII (freehand on rear face)
Notes: L&D Group 1.

47.27) Lead ingot L&D1 35
Type: D2a
Metrics: l. 50 cm, w. 15 cm, h. 12.2 cm; back l. 41.2 cm; m. 51.2 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.4 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖЖЖIIX (freehand on front face)
Notes: L&D Group 1.

47.28) Lead ingot L&D1 36
Type: D2a
Metrics: l. 49.4 cm, w. 14.6 cm, h. 12.1 cm; back l. 41.3 cm; m. 51 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.2 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖIIX (freehand on front face)
Notes: L&D Group 1.

47.29) Lead ingot L&D1 37
Type: D2a
Metrics: l. 49.4 cm, w. 14.5 cm, h. 11.6 cm; back l. 41.6 cm; m. 51 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.6 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖIIX (freehand on front face)
Notes: L&D Group 1.

47.30) Lead ingot L&D1 38
Type: D2a
Metrics: l. 49.5 cm, w. 14.3 cm, h. 12 cm; back l. 41.1 cm; m. 50.9 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.2 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖVII (freehand on rear face)
Notes: L&D Group 1.

47.31) Lead ingot L&D1 40
Type: D2a
Metrics: l. 49.3 cm, w. 14.5 cm, h. 12.2 cm; back l. 41.7 cm; m. 50.85 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.6 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)

Notes: L&D Group 1.

47.32) Lead ingot L&D1 41
Type: D2a
Metrics: l. 49.4 cm, w. 14.5 cm, h. 12.3 cm; back l. 42 cm; m. 52.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.2, w. 8.4 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIIII (freehand on front face)
Notes: L&D Group 1.

47.33) Lead ingot L&D1 42
Type: D2a
Metrics: l. 49.2 cm, w. 14.8 cm, h. 12 cm; back l. 41.6 cm; m. 51.85 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.5 cm, w. 7.8 cm)
Secondary Markings/Features:
b) […]VN (stamped on front face)
c) ZETH (stamped on front face)
Notes: L&D Group 1.

47.34) Lead ingot L&D1 43
Type: D2a
Metrics: l. 50.2 cm, w. 15 cm, h. 11.9 cm; back l. 42 cm; m. 53.2 kg
Mold Mark(s):
a) M[….]IO[.]M (cartouche l. 25.7 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped once on front face and once on right end)
c) ZETH (stamped twice on front face and twice on right end)
d) ЖXIII (freehand on front face)
Notes: Not all stamps are complete. L&D Group 1.

47.35) Lead ingot L&D1 44
Type: D2a
Metrics: l. 49.4 cm, w. 15 cm, h. 11.8 cm; back l. 41 cm; m. 51.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.1 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXI (freehand on front face)
Notes: L&D Group 1.

47.36) Lead ingot L&D1 45
Type: D2a
Metrics: l. 50 cm, w. 15.5 cm, h. 11.7 cm; back l. 41.5 cm; m. 52.0 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.8 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖX (freehand on front face)
Notes: L&D Group 1.

47.37) Lead ingot L&D1 46
Type: D2a
Metrics: l. 49.6 cm, w. 15.2 cm, h. 11.7 cm; back l. 41.5 cm; m. 53.1 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.8 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped twice on rear face)
d) ЖX (freehand on front face)
Notes: L&D Group 1.

47.38) Lead ingot L&D1 47
Type: D2a
Metrics: l. 49.7 – 50 cm, w. 15.5 cm, h. 11.9 cm; back l. 41.6 cm; m. 52.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.5 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXV (freehand on front face)
Notes: L&D Group 1.

47.39) Lead ingot L&D1 48
Type: D2a
Metrics: l. 50.5 cm, w. 15.5 cm, h. 11.9 cm; back l. 41.5 cm; m. 52.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.5 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on front face)
c) ZETH (stamped twice on front face)
d) ЖXIII (freehand on rear face)

Notes: Not all stamps are complete. L&D Group 1.

47.40) Lead ingot L&D1 49
Type: D2a
Metrics: l. 49.4 cm, w. 15.5 cm, h. 11.7 cm; back l. 41.4 cm; m. 52.1 kg
Mold Mark(s):
a) MINVCIORV[.] (cartouche l. 25.5 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXI (freehand on front face)
Notes: L&D Group 1.

47.41) Lead ingot L&D1 50
Type: D2a
Metrics: l. 49.5 cm, w. 16 cm, h. 11.9 cm; back l. 41.5 cm; m. 51.9 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.5 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXV (freehand on rear face)
Notes: L&D Group 1.

47.42) Lead ingot L&D1 51
Type: D2a
Metrics: l. 50.1 cm, w. 15.3 cm, h. 11.7 cm; back l. 41 cm; m. 52.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 26.8 cm, w. 7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on front face)
c) ZETH (stamped on front face)
d) ЖXIII (freehand on rear face)
Notes: L&D Group 1.

47.43) Lead ingot L&D1 52
Type: D2a
Metrics: l. 50 cm, w. 15.2 cm, h. 12 cm; back l. 41.5 cm; m. 52.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on rear face)
c) ZETH (stamped twice on rear face)
d) ЖXI (freehand on front face)
Notes: L&D Group 1.

47.44) Lead ingot L&D1 53
Type: D2a
Metrics: l. 49.5 cm, w. 16 cm, h. 11.8 cm; back l. 41.5 cm; m. 52.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIIII (freehand on rear face)
Notes: L&D Group 1.

47.45) Lead ingot L&D1 54
Type: D2a
Metrics: l. 49.5 cm, w. 15 cm, h. 11.5 cm; back l. 41 cm; m. 50.9 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXI (freehand on rear face)
Notes: L&D Group 1.

47.46) Lead ingot L&D1 55
Type: D2a
Metrics: l. 50 cm, w. 15.3 cm, h. 11.8 cm; back l. 41.5 cm; m. 51.7 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped twice on rear face)
d) ЖXI (freehand on rear face)
Notes: Not all stamps are complete. L&D Group 1.

47.47) Lead ingot L&D1 56
Type: D2a
Metrics: l. 49.7 cm, w. 15.2 cm, h. 11.7 cm; back l. 41.3 cm; m. 51.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXI (freehand on front face)

Notes: Not all stamps are complete. L&D Group 1.

47.48) Lead ingot L&D1 57
Type: D2a
Metrics: l. 50 cm, w. 15.2 cm, h. 12.1 cm; back l. 41 cm; m. 50.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.7 cm)
Secondary Markings/Features:
b) AP. IVN (stamped three times on rear face)
c) ZETH (stamped twice on rear face)
d) ЖX (freehand on rear face)
Notes: L&D Group 1.

47.49) Lead ingot L&D1 59
Type: D2a
Metrics: l. 49.5 cm, w. 14.8 cm, h. 11.9 cm; back l. 41.1 cm; m. 50.0 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIII (freehand on rear face)
Notes: L&D Group 1.

47.50) Lead ingot L&D1 60
Type: D2a
Metrics: l. 49.8 cm, w. 15.5 cm, h. 11.7 cm; back l. 41.2 cm; m. 51.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXII (freehand on front face)
Notes: L&D Group 1.

47.51) Lead ingot L&D1 61
Type: D2a
Metrics: l. 49.9 cm, w. 15.3 cm, h. 11.7 cm; back l. 41 cm; m. 51.3 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖIIX (freehand on front face)
Notes: L&D Group 1.

47.52) Lead ingot L&D1 62
Type: D2a
Metrics: l. 49.8 cm, w. 15.5 cm, h. 11.9 cm; back l. 41.2 cm; m. 50.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXIII (freehand on front face)
Notes: L&D Group 1.

47.53) Lead ingot L&D1 63
Type: D2a
Metrics: l. 49.5 cm, w. 15.5 cm, h. 11.8 cm; back l. 41.2 cm; m. 51.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXI (freehand on front face)
Notes: L&D Group 1.

47.54) Lead ingot L&D1 64
Type: D2a
Metrics: l. 49.6 cm, w. 15.5 cm, h. 11.6 cm; back l. 41.3 cm; m. 50.4 kg
Mold Mark(s):
a) MINVCIO[…] (cartouche dimensions not detectable)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖV (freehand on front face)
Notes: L&D Group 1.

47.55) Lead ingot L&D1 65
Type: D2a
Metrics: l. 49.7 cm, w. 15.5 cm, h. 11.8 cm; back l. 41.4 cm; m. 52.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXV (freehand on rear face)

Notes: L&D Group 1.

47.56) Lead ingot L&D1 66
Type: D2a
Metrics: l. 50.3 cm, w. 15.5 cm, h. 12 cm; back l. 41.2 cm; m. 53.2 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXVI (freehand on front face)
Notes: L&D Group 1.

47.57) Lead ingot L&D1 67
Type: D2a
Metrics: l. 49.7 cm, w. 15.3 cm, h. 11.8 cm; back l. 41.4 cm; m. 51.7 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖIX (freehand on rear face)
Notes: L&D Group 1.

47.58) Lead ingot L&D1 68
Type: D2a
Metrics: l. 49.5 cm, w. 15.5 cm, h. 11.8 cm; back l. 41.2 cm; m. 51.3 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖIX (freehand on front face)
Notes: L&D Group 1.

47.59) Lead ingot L&D1 69
Type: D2a
Metrics: l. 49 cm, w. 15 cm, h. 11.5 cm; back l. 41.3 cm; m. 50.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8.0 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXII (freehand on front face)
Notes: L&D Group 1.

47.60) Lead ingot L&D1 70
Type: D2a
Metrics: l. 49 cm, w. 15.5 cm, h. 11.95 cm; back l. 41.2 cm; m. 52.1 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.9 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXII (freehand on rear face)
Notes: L&D Group 1.

47.61) Lead ingot L&D1 71
Type: D2a
Metrics: l. 49.2 cm, w. 15 cm, h. 11 cm; back l. 41.2 cm; m. 47.9 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l.. 25 cm, w. 8.3 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ~~IIII~~ XII (freehand on front face)
Notes: L&D Group 1.

47.62) Lead ingot L&D1 73
Type: D2a
Metrics: l. 50 cm, w. 15.3 cm, h. 11.7 cm; back l. 41 cm; m. 50.0 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped twice on front face)
d) ЖV (freehand on front face)
Notes: L&D Group 1.

47.63) Lead ingot L&D1 74
Type: D2a
Metrics: l. 49.6 cm, w. 15.6 cm, h. 11.6 cm; back l. 41.5 cm; m. 53.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXVI (freehand on front face)
Notes: L&D Group 1.

47.64) Lead ingot L&D1 75
Type: D2a
Metrics: l. 50 cm, w. 15.5 cm, h. 11.9 cm; back l. 41.1 cm; m. 53.5 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on rear face, once on right end)
c) ZETH (stamped twice on rear face, once on right end)
d) ЖXV (freehand on front face)
Notes: L&D Group 1.

47.65) Lead ingot L&D1 76
Type: D2a
Metrics: l. 50.5 cm, w. 15.2 cm, h. 10.7 cm; back l. 40.5 cm; m. 47.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.2 cm)
Secondary Markings/Features:
c) ZETH (stamped once on front face, three times on left end)
d) ~~IIII~~ VII (freehand on rear face)
Notes: L&D Group 1.

47.66) Lead ingot L&D1 77
Type: D2a
Metrics: l. 49.5 cm, w. 14.9 cm, h. 11.6 cm; back l. 41.2 cm; m. 50.8 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) IЖIX (freehand on rear face)
Notes: L&D Group 1.

47.67) Lead ingot L&D1 78
Type: D2a
Metrics: l. 49.5 cm, w. 15.5 cm, h. 11.6 cm; back l. 41.1 cm; m. 51.1 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖIIX (freehand on rear face)
Notes: L&D Group 1.

47.68) Lead ingot L&D1 79
Type: D2a
Metrics: length and width not given, h. 11.7 cm; back l. 41.4 cm; m. 53.05 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXII (freehand on rear face)
Notes: L&D Group 1.

47.69) Lead ingot L&D1 82
Type: D2a
Metrics: length and width not given, h. 11.8 cm; back l. 41.2 cm; m. 50.7 kg
Mold Mark(s):
a) MINVC[.]ORVM (cartouche l. 25 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖX (freehand on rear face)
Notes: L&D Group 1.

47.70) Lead ingot L&D1 83
Type: D2a
Metrics: l. 49.7 cm, w. 15-15.2 cm, h. 11.45 cm; back l. 41 cm; m. 51.7 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖX (freehand on rear face)
Notes: L&D Group 1.

47.71) Lead ingot L&D1 84
Type: D2a
Metrics: l. 49.9 cm, w. 15-16 cm, h. 11.3 cm; back l. 41 cm; m. 52.6 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 7.7 cm)
Secondary Markings/Features:
b) [..]. IVN (stamped twice on front face)
c) ZETH (stamped on front face)
d) ЖXIIII (freehand on front face)
Notes: L&D Group 1.

47.72) Lead ingot L&D1 85
Type: D2a
Metrics: l. 50 cm, w. 15 cm, h. 11.85 cm; back l. 41.2 cm; m. 52.3 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.4 cm, w. 7.8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXII (freehand on rear face)
Notes: L&D Group 1.

47.73) Lead ingot L&D1 86
Type: D2a
Metrics: l. 49.8 cm, w. 15.5 cm, h. 11.85 cm; back l. 41.2 cm; m. 52.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25.3 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped twice on rear face, once on right end)
c) ZETH (stamped once on rear face, once on right end)
d) ЖX (freehand on rear face)
Notes: Not all stamps complete. L&D Group 1.

47.74) Lead ingot L&D1 87
Type: D2a
Metrics: l. 49.5 cm, w. 15.5-15.7 cm, h. 12.2 cm; back l. 41 cm; m. 50.95 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped once on front face, twice on rear face)
c) ZETH (stamped once on twice front face, once on rear face)
d) ЖXIIII (freehand on rear face)
Notes: Not all stamps complete. L&D Group 1.

47.75) Lead ingot L&D1 88
Type: D2a
Metrics: l. 49.7 cm, w. 15.9 cm, h. 11.8 cm; back l. 41.2 cm; m. 51.0 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 26.6 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖXI (freehand on rear face)
Notes: L&D Group 1.

47.76) Lead ingot L&D1 89
Type: D2a
Metrics: l. 49.5 cm, w. 15-15.3 cm, h. 11.7 cm; back l. 41.4 cm; m. 51.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8.2 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on rear face)
c) ZETH (stamped on rear face)
d) ЖV (freehand on front face)
Notes: L&D Group 1.

47.77) Lead ingot L&D1 91
Type: D2a
Metrics: l. 50.2 cm, w. 15 cm, h. 11.85 cm; back l. 41.8 cm; m. 53.4 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped three times on rear face, once on left end)
c) ZETH (stamped twice on rear face, once on left end)
d) ЖXI (freehand on rear face)
Notes: Not all stamps complete. L&D Group 1.

47.78) Lead ingot L&D1 92
Type: D2a
Metrics: l. 49.5-50 cm, w. 14.5-15 cm, h. 11.65 cm; back l. 41 cm; m. 52.1 kg
Mold Mark(s):
a) MINVCIORVM (cartouche l. 25 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) [.]ETH (stamped on front face)
d) ЖX (freehand on front face)
Notes: L&D Group 1.

47.79) Lead ingot L&D1 93
Type: D2a
Metrics: l. 49.9 cm, w. 14.9 cm, h. 13 cm; back l. 41.6 cm; m. 50.55 kg
Mold Mark(s):

a) MINVCIORVM (cartouche l. 25.4 cm, w. 8 cm)
Secondary Markings/Features:
b) AP. IVN (stamped on front face)
c) ZETH (stamped on front face)
d) ЖXII (freehand on front face)
Notes: L&D Group 1.

47.80) Lead ingot L&D1 4
Type: D2a
Metrics: l. 51 cm, w. 14.2 cm, h. 12.3 cm; back l. 41.5 cm; m. 52.1 kg
Mold Mark(s):
a) [.]IN[…….] (cartouche l. 24.8 cm, w. 8.1 cm)
Secondary Markings/Features:
b) AP. IVNI (stamped on front face)
c) ZETH (stamped on front face)
Notes: L&D Group 2.

47.81) Lead ingot L&D1 11
Type: D2a
Metrics: l. 50.5 cm, w. 14.4 cm, h. 12.7 cm; back l. 42.2 cm; m. 53.4 kg
Mold Mark(s):
a) [M]INVCIORVM (cartouche l. 25.2 cm, w. 8.2 cm)
Secondary Markings/Features:
b) ZETH (stamped on front face)
c) [...] IVN (stamped on front face)
d) ЖXVI (freehand on rear face)
Notes: L&D Group 2.

47.82) Lead ingot L&D1 12
Type: D2a
Metrics: l. 49 cm, w. 13.9 cm, h. 11.6 cm; back l. 41.2 cm; m. 51.75 kg
Mold Mark(s):
a) [.]INVCIO[..]M (cartouche l. 24.8 cm, w. 8.2 cm)
Secondary Markings/Features:
b) ZETH (stamped once on front face)
c) [...] IVN (stamped once on front face)
d) ЖXVII (freehand on rear face)
Notes: L&D Group 2.

47.83) Lead ingot L&D1 15
Type: D2a
Metrics: l. 50.5 cm, w. 11.5 cm, h. 12 cm; back l. 41 cm; m. 52.75 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. 24.6 cm, w. 7.9 cm)
Secondary Markings/Features:
b) ZETH (stamped on rear face)
c) AP. IVN (stamped rear face)
d) ЖXIIII (freehand on front face)
Notes: L&D Group 2.

47.84) Lead ingot L&D1 20
Type: D2a
Metrics: l. 50 cm, width and height not given; back l. 41 cm; m. 53.1 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. 24.6 cm, w. 7.9 cm)
Secondary Markings/Features:
b) ZETH (stamped once on front face, twice on left end)
c) AP. IVN (stamped once on front face, twice on left end)
d) ЖXIII (freehand on rear face)
Notes: L&D Group 2.

47.85) Lead ingot L&D1 23
Type: D2a
Metrics: l. 50 cm, w. 14.5 cm, h. 12.6 cm; back l. 41.2 cm; m. 53.1 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. not given, w.7.6 cm)
Secondary Markings/Features:
b) ZETH (stamped on front face)
c) AP. IVN (stamped on front face)
d) ЖXV (freehand on rear face)
Notes: L&D Group 2.

47.86) Lead ingot L&D1 27
Type: D2a
Metrics: l. 50 cm, w. 14.5 cm, h. 12.6 cm; back l. 41.2 cm; m. 53.1 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. 24.3 cm, w. 8.2 cm)
Secondary Markings/Features:
b) ZET[.] (stamped on front face)
c) AP. IVN (stamped on front face)
Notes: L&D Group 2.

47.87) Lead ingot L&D1 34
Type: D2a
Metrics: l. 50.8 cm, w. 14.6 cm, h. 12 cm; back l. 41.5 cm; m. 52.6 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. 24.4 cm, w. 8.6 cm)

Secondary Markings/Features:
b) ZETH (stamped on front face)
c) AP. IVN (stamped on front face)
d) ЖXIII (freehand on front face)
Notes: L&D Group 2.

47.88) Lead ingot L&D1 39
Type: D2a
Metrics: l. 50.6 cm, w. 14.9 cm, h. 12.3 cm; back l. 41.5 cm; m. 53.2 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche 24.9 x 7.9 cm)
Secondary Markings/Features:
b) ZETH (stamped twice on front face)
c) AP. IVN (stamped on front face)
d) ЖXVI (freehand on rear face)
Notes: L&D Group 2.

47.89) Lead ingot L&D1 58
Type: D2a
Metrics: l. 50.3 cm, w. 14.5 cm, h. 12.5 cm; back l. 41.5 cm; m. 53.1 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. 24.3 cm, w. 8.3 cm)
Secondary Markings/Features:
b) ZETH (stamped twice on rear face)
c) [..]. IVN (stamped on rear face)
d) ЖXIII (freehand on rear face)
Notes: Not all stamps complete. L&D Group 2.

47.90) Lead ingot L&D1 72
Type: D2a
Metrics: l. 50.5 cm, w. 15.3 cm, h. 12.1 cm; back l. 41 cm; m. 53.1 kg
Mold Mark(s):
a) [.]INVC[….]M (cartouche l. 24.2 cm, w. 8 cm)
Secondary Markings/Features:
b) [.]ETH (stamped on rear face)
c) AP. IVN (stamped on rear face)
d) ЖXV (freehand on rear face)
Notes: L&D Group 2.

47.91) Lead ingot L&D1 81
Type: D2a
Metrics: l. 51 cm, w. 15 cm, h. 12.15 cm; back l. 41 cm; m. 53.5 kg
Mold Mark(s):
a) [.]INVCIORVM (cartouche l. 24.4 cm, w. 8 cm)
Secondary Markings/Features:
b) ZETH (stamped on rear face)
c) [..]. IVN (stamped twice on rear face)
d) ЖXVII (freehand on front face)
Notes: L&D Group 2.

47.92) Lead ingot L&D1 90
Type: D2a
Metrics: l. 50.7-51.0 cm, w. 15 cm, h. 11.9 cm; back l. 41 cm; m. 51.2 kg
Mold Mark(s):
a) [.]IN[..]IOR[.]M (cartouche l. 24.5 cm, w. 8 cm)
Secondary Markings/Features:
b) ZETH (stamped on rear face)
c) AP. IVN (stamped on rear face)
d) ЖXI (freehand on front face)
Notes: L&D Group 2.

47.93) Lead ingot L&D1 80
Type: D2a
Metrics: l. 50.3 cm, w. 15.3 cm, h. 12.4 cm; back l. 41.5 cm; m. 53.25 kg
Mold Mark(s):
a) M[.]NVCIORVM (cartouche l. 24.5 cm, w. 8.4 cm)
Secondary Markings/Features:
b) ZETH (stamped on rear face)
c) AP. IVN (stamped on rear face)
d) ЖXVI (freehand on front face)
Notes: L&D Group 3.

48) Lavezzi A

Alternate Names: Lavezzi 1
Region: Straits of Bonifacio (IT) *BA* 48:D3
Date: 1-50 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 5
Discussion: This site, discovered during a series of surveys between 1958 and 1960, consists of what may have been two separate consignments of Spanish agricultural products, most likely fish products and olive oil, one in the bow and one in the stern. In addition there was a significant quantity of copper ingots (at least 18), both rectangular and discoid, weighing between 15 and 40 kg each. The discoid ingots were incised with freehand letters, believed to be weight indicators, and were described by Benoit as being chemically consistent with other copper ingots from the Sierra Morena region.

Bebko reported finding four lead ingots, but only three were published in detail in *LLGS*, and Liou discovered five upon re-examining the collection; Parker states there were at least seven. The site was heavily looted, making it difficult to assess whether the ingots were part of the cargo rather than ship's supplies, although the presence of copper ingots suggests a metal cargo component. An unmarked flat bar of lead with a bend in the center was also reported and is likely to have been part of the ship's stores.[741] Square nail holes were reported in both ends of each ingot (cf. 36, 41, 45, 57). Inventory numbers cited are from Musée d'Ethnographie, Bastia (MEB). References: Benoit 1962, 174-6; Bebko 1971, 2, 4, figs. 115-120; *LLGS* 10-29, 114-9; Liou 1990, 144-9; Parker 1992a, 238.

48.1) Lead ingot DOM 02-901[742]; LLGS 13; MEB inv. D64.263
Type: D2a
Metrics: l. 50.5 cm, w. 15.5 cm, h. 12 cm; back l. 41 cm; m. 54.5 kg.
Mold mark(s):
a) […] (cartouche l. 23 cm, w. 2.4 cm)
Secondary Markings/Features:
b) M·B·A (relief stamped four times, twice on each end)
c) L·AVṚ (AVR in ligature; freehand once on one end, and once on one face.)
Notes: There is a cartouche on the back but no inscription is discernible; the cartouche is partially filled in (3.5 cm) with additional lead, interpreted in *LLGS* as overflow from the tap hole. Due to the loss of the top portions of the penultimate and final letters, inscription (c) has been variously restored as L·AM, L·AML, and L·AVR. The third interpretation has been adopted here, in accordance with Liou 1990, who proposes a restoration of *L(uci) Aur(eli)* but with no correlates. Nail holes penetrate each end diagonally down through the base.[743] Qualitative chemical analysis showed minor levels of Cu, Ag, Sb, and Bi, and trace levels of Ni and Fe; no traces of Sn, As, Au, Zn or Co were found. Found in association with 48.3.

48.2) Lead ingot DOM 02-902; LLGS 11; MEB inv. D.64.261.1[744]
Type: D2a
Metrics: l. 49.5 cm, w. 14.5 cm, h. 11.5 cm; back l. 40.5 cm; m. 51.5 kg.
Mold mark(s):
a) […] (cartouche l. 26.5 cm, w. 2.1 cm)
Secondary Markings/Features:
b) I… (stamped on one end)
c) L (freehand on opposite end)
Notes: There is a cartouche in back but no inscription is discernible. Inscription (b) may be the edge of an M·B·A stamp as in 36.1b, and inscription (c) may correspond to the L·AVR of 36.1c. Nail holes penetrate each end diagonally down through the base. Qualitative chemical analysis showed minor levels of Cu, Ag, Sb, and Bi, and trace levels of Ni and Fe; no traces of Sn, As, Au, Zn or Co were found.

48.3) Lead ingot DOM 02-903; LLGS 12; MEB inv. D64.264
Type: D2a
Metrics: l. 49 cm, w. 15 cm, h. 12.5 cm; back l. 41 cm; m. 44.5 kg.[745]

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[741] This bar is similar to one found on the Cap Spartel wreck (**29**) and on Bajo de la Campana A (**5**), but with a less formalized shape and shallower bend.
[742] Throughout the entry, dimensions reported by Liou 1990 have been taken to supersede those of early sources, as they represent the most recent assessment, reflecting the current condition of the ingots. Liou used the catalog numbers assigned by C. Domergue in his as-yet-unpublished catalog of lead ingots from Spain (*DOM*).
[743] See Bebko 1971, Fig. 115. This was not mentioned in *LLGS* but has been confirmed by Liou (1990).
[744] This ingot was originally published with the MEB inventory number D64.36.1; the number published in Liou (1990) is taken as the correct one.
[745] This figure is significantly lower than those reported in *LLGS* (56 kg) and by Domergue

Mold mark(s):
a) [C…..C..O…..] (cartouche l. 30 cm, w. 2.5 cm)
Secondary Markings/Features:
b) M·B·A (relief stamped twice on one end)
c) L·ẠṾṚ (freehand on opposite end; AVR in ligature; final letters incomplete and restored based on stamp on 36.1)
Notes: There is a cartouche in back with only traces of the inscription discernible. Nail holes penetrate each end diagonally down through the base. Qualitative chemical analysis showed minor levels of Cu, Ag, Sb, and Bi, and trace levels of Ni and As; no traces of Sn, As, Au, Zn, Fe or Co were found. Found in association with 48.1

48.4) Lead ingot DOM 02-904; Bebko 1971, Fig. 119-120; MEB inv. D.73.1.8
Type: D2a
Metrics: l. 49.5 cm, w. 15.5 cm, h. 13 cm; back l. 40.5 cm; m. 52.5 kg.
Mold mark(s):
a) […] (cartouche l. 28.5 cm, w. 2.5 cm)
Secondary Markings/Features:
b) Ṃ·Ḅ·Ạ (stamped on one end; only the bottom of the letters are preserved)
c) L·ẠṾṚ (freehand on opposite end; heavily concreted)
Notes: There is a cartouche on the back; a partial inscription was represented in the original drawing,[746] but Liou reports that nothing legible now remains. Other marks reported by Bebko appear to Liou to be small scratches with no epigraphical intent. Oblique nail holes penetrate the base, three at one end and four at the other.

48.5) Lead ingot Bebko 1971, Fig. 119-120
Type: D2a
Metrics: l. 50 cm, w. 15 cm, h. 11 cm; back l. 41.5; m. 46.0 kg.
Mold mark(s):
a) P̣ F…Ṣ… (cartouche l. 30.5 cm, w. 2.4 cm)
Secondary Markings/Features:
b) M·B·A (stamped twice on left end, and once on right end)
c) IIII (freehand on front face, at right)
d) I (freehand on front face, at left)
Notes: Inscription (a) is partially restored as *P(ubli)*; the F is in a position to suggest it may be the beginning of a *nomen* rather than the abbreviation *f(ilii).* Oblique nail holes penetrate the base at each end.

49) Les Sorres C
Alternate name: Les Sorres IIIa
Region: Catalonia (ES) *BA* 25:G/H4
Date: 1-50 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: ±20
Discussion: Unearthed during quarrying efforts in the delta of the Llobregat River between 1965 and 1975, these ingots and many other finds from the ancient anchorage were dispersed to private collectors, lost or destroyed. While approximately 20 ingots were documented through photographs and oral reports, only 1 was listed as surviving in a private collection. They were found in association with a dolium and several local Dressel 2/4 amphorae, as well as some lead pipes. Parker gives an approximate weight of 43 kg, distinctly heavier than the standard Roman ingots of the Republican period but consistent with some finds believed to originate from the Sierra Morena (see Port Vendres B (**51**) and Sud Perduto B (**45**)). No shape or general description is provided. A nearby wreck, dated somewhat earlier, contained iron ore (Les Sorres IV) attesting to other metal transport in the region.
References: Izquierdo 1987; Izquierdo and Solias 1991; Parker 1992, 408-9.

50) Ile Rousse
Alternate names: Isula Rossa; l'épave aux dolia de l'Ile Rousse
Region: Western Corsica *BA* 48:C2
Date: mid 1st c. C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 1
Discussion: The primary cargo of this wreck, discovered in 1971, consisted of

(55.8 kg), but Liou affirms its accuracy (Liou 1990, 147).
[746] Bebko 1971, Fig. 119.

amphorae (Dressel 2-4) and dolia, with suspected origins in Hispania Tarraconensis and Gaul. Only one ingot was found, in the galley area, indicating it was likely part of the ship's supplies, although the site had been partially looted before excavation. Alfonsi and Gandolfi suggest the lead may have been used to make seals for the dolia. Some suspect a Gaulish origin for this ingot, and Domergue and Liou have argued for Spanish; given the recent confirmation of GERM as a marker of German production (see Appendix B), this ingot likely originated in Germania.
References: Liou 1973; Alfonsi and Gandolfi 1989; Parker 1992a, 214; Domergue 1994, 82-3; Domergue and Liou 1997, 18-19.

50.1) Lead ingot
Type: D4.2
Metrics: l. 63 cm, w. 16 cm, h. 10 cm; back l. 50 cm, w. 7 cm; m. 75 kg
Mold mark(s):
a) CAESAR·AVGIMP·GERM·TFCF (cartouche l. 47.6 cm, w. 4 cm)
Secondary Markings/Features:
b) P R A A A G (stamped nine times on rear face)
c) XXV (freehand on front face)
d) LXXVIIII (freehand or punched on left end)
Notes: First part of inscription (a) was originally interpreted as *Caesar Aug(ustus) Imp(erator) Germ(anicus)*, placing this ingot in the reign of the emperor Caligula. Given the recent evidence for ingots from Germany (cf. 60), however, the GERM may relate to the region of origin rather than the emperor.[747] *TFCF* (or possibly *TECE*) could not be interpreted. Frequent overstrikes of (b) make them difficult to read, and no interpretation has been offered. The numeral (d) is considered a weight designation based on a 150-*libra* standard. Numeral (c) may be a serial number.

51) Port Vendres B
Alternate names: Port-Vendres 2
Region: Pyrénées-Orientales *BA* 25:I3
Date: 42-48 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 3
Discussion: This ship, discovered in 1972, carried a heterogeneous cargo, including Baetican agricultural products in marked amphorae (Dressel 20, Dressel 28, Haltern 70), *terra sigillata* of Gaulish and Arretine origin, as well as at least 18 tin, 2 copper and 3 lead ingots. The date of the materials is primarily based upon an inscription on many of the tin ingots, referring to Valeria Messalina, third wife of Claudius.[748] The low number of lead ingots suggests they were part of the ship's stores, but as the cargo was so very diverse, it is possible they were part of small consignment of metals. Colls and colleagues suggest an origin in the Sierra Morena range based on the likely origin of other components of the cargo, but this has yet to be confirmed with lead isotope analysis.
References: Colls et al. 1977, 11-22; Parker and Price 1981; Parker 1992a, 330.

51.1) Lead ingot Colls et al. 1977: 1
Type: D2a
Metrics: l. 51.2 cm, w. 15 cm. h. 12.5 cm; back l. 44.7 cm; m. 59.6 kg
Mold mark(s):
a) …...HEL..AṾ... (both groups of letters in ligature; cartouche l. 24.9 cm , w. 2.5 cm)
Notes: An alternate suggestion for AV was ANT.

51.2) Lead ingot Colls et al. 1977: 2
Type: D2a
Metrics: l. 51.6 cm, w. 14.6 cm. h. 10 cm; back l. 38.2 cm; m. approx. 44 kg
Mold mark(s):

[747] If this were so, however, with CAESAR apparently in the nominative, it is difficult to construe the proper case for *(plumbum) Germ(anicum)*. See also Appendix B.

[748] The full inscription as restored is *L(ucius) Vale(rius), Aug(ustae) l(ibertus), a com(mentariis)*.

a) Ṃ HẸḶV.Ṃ... (cartouche l. 17 cm , w. 2.2-2.3 cm)
Notes: Inscription (a) was heavily damaged, and reconstructed in part from 41.3a. Taken with 51.1, the most complete reading is M·HELVI·M…AV.. [749] The name *Marcus Helius* has been suggested, although this name has not yet been attested on other ingots. An extra width of lead juts out from the base which appears to have been overflow from the mold.

51.3) Lead ingot Colls et al. 1977: 3
Type: D2a
Metrics: l. 51.6 cm, w. 14.5 cm. h. 9.7 cm; back l. 38.5 cm; m. approx. 44 kg
Mold mark(s):
a) Ṃ HẸḶV.Ṃ... (cartouche l. 16.6 cm , w. 2.5 cm)
Notes: See **51.2** for details on inscription (a). Based on metric similarities with **41.2**, this may have come from the same mold.

52) Mljet
Alternate Names: Cape Glavat
Region: Dalmatia *BA* 20:E7
Date: 1st c. C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: none, lead minerals only
Discussion**:** This ship carried a heterogeneous cargo that included raw glass, semi-finished glass materials, lead minerals and ceramic tableware of central Italian origin, as well as several Dressel 21/22 amphorae. The lead products consisted of jars of red lead (lead tetroxide), white cubes of lead carbonate and dark grey cubes of galena (lead sulfide). All of these minerals had uses as colorants or glazes, but also had medicinal applications. The minerals are believed to have originated in the mines around modern Srebrenica, although the glass was most likely produced in the Near East, making the route of this ship difficult to deduce.
References: Radić and Jurišić 1993; Radić Rossi 2005.

53) Istria
Region: Istria *BA* 20:A5
Date: 1st c. C.E.?
Cultural Affiliation: Roman
Number of Lead Ingots Found: unknown large quantity
Discussion: This site, discovered in 1924 and not formally excavated,[750] reportedly yielded "an enormous quantity" of lead ingots spread over a 4 km^2 area. Such a wide dispersal of lead is unusual, even in high energy environments,[751] and may reflect an attempt to unload cargo to prevent sinking. Their shape was described as a triangular prism, which is consistent with Roman production of type D2 or D4, suggesting an Imperial date. The ingots were approximately 50 cm. in length. No inscriptions were mentioned. A large number of lead anchor stocks were also found in the area, but due to high loss rates of these items, they cannot be firmly associated with the ingots.
References: Nikonlanci 1961, 25; Parker 1992a, 221.

54) Baie de l'Amitié *BA* 15:A3
Alternate names: Battuts 2
Region: Hérault (FR)
Date: 50-100 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 98
Discussion: This site, looted soon after its discovery in 1983, contained a large consignment of Dressel 20 amphorae, at

[749] This restoration was accepted by Domergue (1990, tab. X, cat. 2002).

[750] All ingots were recovered by non-professional divers and sold for scrap; details were related to Nikolanci by a local fisherman.
[751] The Sancti Petri wreck (57) was found in a zone with heavy tidal currents, but the ingot spread was still concentrated in an area of less than 100 m^2 and "it seemed as if the materials had stayed at the spot in which they happened to fall after the eventual shipwreck, buried sideways or even stuck vertically in the sand, one over the other, neatly piled" (Vallespin Gomez 1986, 308 and Fig. 4).

least 2.8 tons of lead ingots, as well as some coarseware pots, and *terra sigillata* of Arretine and southern Gaulish origin. One amphorae handle was stamped LCM, interpreted as *L(ucius) C(aelius) M(oderatus* or *..artius*), linking that portion of the cargo to the northern Gaudalquivir valley. This seemed to suggest that the ingots, which were loaded beneath the amphorae, originated from Sierra Morena range. Samples from several ingots were tested isotopically, however, and found to be consistent with ores from the Sierra de Cartagena region.[752] This is the latest attestation yet found of output from this region, proving that even though lead production had waned in that area in the first century C.E., it had not ceased altogether.

The ingots ranged from 5 to 43 kg and are described as having been cast in a mold, with a flat base and rounded back, suggesting they are type D1, but with some lateral asymmetry. No cartouches are present, but mold marks in the form of a symbol or image in relief are common, including a snail shell, large bars, and possibly a gorgon's head; impressed V's are also reported on some. Other finds of ingots with only image-based mold marks include Punta della Contessa (**67**) and Rena Maiore (**46.3**).

References: Pomey et al. 1989, 5; Parker 1992a, 65.

55) Marseillan Plage B

Alternate names: Riches Dunes 2
Region: Hérault BA 15:B3
Date: 50 -100 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 17
Discussion: This site, discovered in 1984, showed evidence of a classic Iberian heterogeneous cargo of agricultural and mineral products. In addition to the lead ingots, four copper ingots with freehand numerals and amphorae fragments were found. One Dressel 29 amphora handle has a stamp (CSEM) that may be the same as one found on the Port-Vendres B wreck (**51**), thus providing a possible date for this wreck.
References: Pomey et al. 1989, 6; Parker 1992a, 265

55.1) 17 lead ingots

Type: D2 or D4
Metrics: (averages for group): l. 42 cm, w. 11.5-13 cm, h. 10 cm; m. 32-34 kg
Mold mark(s): Remains of inscriptions appeared on two ingots, but no letters could be construed.
Notes: The ingots were reported as truncated pyramidal in shape, which might describe both types D2 and D4.

56) Ses Salines

Alternate names: Cabrera 6
Region: Balearic Islands *BA* 27:inset
Date: 69-79 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 50+ reported; 17 published in detail (Veny 1969-70), and 3 published summarily (Domergue and Liou 1997).
Discussion: Discovered in 1960, this site was not systematically excavated, and many of the finds have been lost or dispersed to private collectors. A number of Dressel 7 and Dressel 20 amphorae were reported in addition to at least 50 lead ingots, suggesting the vessel carried a heterogeneous cargo of Baetican origin similar to Port Vendres B (**51**), Sud Perduto B (**45**) and Cabrera E (**41**). Some ship timbers with remains of lead sheathing were also discovered.[753] Based on the inscriptions, the ingots appear to date from the reign of Vespasian. Overall, they are rather irregular in profile, some with pronounced dips in the center of the back when viewed from the side, which may be a result of post-depositional wear. Inventory numbers are from the Museo Arqueológico de Barcelona (MAB).

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[752] Trincherini et al. 2009, Table 2.

[753] If the dating of the wreck is correct, this would be one of the latest examples of lead sheathing in the Mediterranean, along with the wreck at Caesarea (59).

References: Veny 1969-70; Parker 1974; Parker 1992a, 378; Domergue and Liou 1997, table 2 (DL).

56.1) Lead ingot Veny 1969-70: 1; DOM 04.001.01

Type: D4.1
Metrics: l. 45 cm, w. 11 cm, h. 9 cm; m. 30 kg
Mold mark(s):
a) ….EMILI GALLICI (cartouche l. 18 cm, w. 1.7 cm)
Secondary Markings/Features:
b) IXXXXIII (inverted, freehand on rear face)
c) IMP·CAES (stamped three times on rear face)
d) I·T·C·F (inverted, stamped(?) on right end)
Notes: Described by Veny as truncated pyramid. Lacuna in (a) restored as [P. A]EMILI based on an ingot found at Pompei,[754] thus the full name would be *P(ublii) Aemili(i) Gallici*. Inscription (b) is construed as a weight of 93 *librae* with the initial *I* functioning as 50; (c) as *Imp(eratoris) Cae(saris)* (cf. stamps from Saintes-Maries-de-la-Mer 1 (**60**)); and (d) *I(mperatoris) T(iti) C(aesaris) F(odinis)*, with some doubt about the final word.

56.2) Lead ingot Veny 1969-70: 2; DOM 04.004.03

Type: D4.1
Metrics: l. 47 cm, w. 10 cm, h. 8 cm; m. approx. 33 kg
Mold mark(s):
a) NE·MEVI·APRI (NE and ME in ligature; cartouche l. 14 cm, w. 3 cm)
Secondary Markings/Features:
b) IXXXXIX (inverted, freehand on rear face)
c) IMP·CAES (stamped three times on rear face)
d) AVG (inverted, stamped on right end)
Notes: Inscription (a) interpreted as *N(umeri) Mevi Apri*, though the normal abbreviaition for this praenomen is normally simply N; (d) stands for *Aug(usti)*, to accompancy (b); (b) and (c) are interpreted as in 56.1.

56.3) Lead ingot Veny 1969-70: 3; DOM 04.004.02

Type: D4.1
Metrics: l. 47 cm, w. 11 cm, h. 9.5 cm; m. 33.75 kg.
Mold mark(s):
a) NE·MEVI·APRI (NE and ME in ligature; cartouche l. 13.5 cm, w. 2.5 cm)
Secondary Markings/Features:
b) V (inverted, freehand on rear face)
c) IMP·CAES (stamped 3 times on front face)
d) AVG (inverted, stamped on left end)
Notes: Inscription (a) interpreted as in 56.2(a); (c) as in 56.1(b); (d) as in 56.2(d). The freehand mark (b) indicates a weight of 105 *librae,* notated as 5 over 100-*libra* standard.

56.4) Lead ingot Veny 1969-70: 4; MAB inv. 17.177; DOM 04.004.01

Type: D4.1
Metrics: l. 46.5 cm, w.10.7 cm, h. 8.5 cm; m: 31.2 kg
Mold mark(s):
a) NE·MEVI·APRI (NE and ME in ligature; cartouche l. 13.5 cm, w. 2.6 cm; ME in ligature)
Secondary Markings/Features:
b) IXXXXVI (freehand on rear face)
c) IMP·CAES (stamped twice on front face)
d) AVG (stamped on right end)
Notes: Inscription (a) interpreted as in 56.2(a); (c) as in 56.1(b); (d) as in 56.2(d). The freehand mark (b) indicates a weight of 96 *librae*.

56.5) Lead ingot Veny 1969-70: 5; DOM 04.002.03

Type: D4.1
Metrics: l. 45 cm, w. 10 cm, h. 9 cm; m: 29.3 kg
Mold mark(s):
a) Q·CORNVTI *double palm* (cartouche l. 19.5 cm, w. 2.5 cm) [755]
Secondary Markings/Features:

[754] *CIL* X, 8339.

[755] This is two palm fronds joined at stem and diverging like a horizontal V.

b) VESP·AVG (stamped three times on rear face)
c) IXXXXI (freehand on front face)
d) AVG (inverted, stamped on right end)
Notes: Inscription (a) interpreted as *Q(uinti) Cornuti(i)*; (b) as *Vesp(asiani) Aug(usti)*; (d) as in 56.2(d); (c) indicates a weight of 91 *librae.*

56.6) Lead ingot Veny 1969-70: 6; DOM 04.002.02
Type: D4.1
Metrics: l. 45.5 cm, w. 10.5 cm, h. 9 cm; m: 30.5 kg
Mold mark(s):
a) Q·CORNVTI *double palm* (cartouche l. 19.5 cm, w.2.5 cm)
Secondary Markings/Features:
b) IXXXXV (freehand on rear face)
c) VESP·AVG (stamped twice (one inverted) on front face)
d) AVG (inverted, stamped on right end)
Notes: Inscription (a) interpreted as in 56.5(a); (c) as in 56.5(b); (d) as in 56.2(d). The freehand mark (b) indicates a weight of 95 *librae*

56.7) Lead ingot Veny 1969-70: 7; MAB inv. 17.178; DOM 04.002.01
Type: D4.1
Metrics: l. 45.5 cm, w. 10.5 cm, h. 9.8 cm; m: 32.5 kg
Mold mark(s):
a) Q·CORNVTI *double palm* (cartouche l. 21 cm, w. 2.6 cm)
Secondary Markings/Features:
b) IMP·CAES (stamped twice on rear face)
c) IXXXXIX (freehand on front face)
d) h-I-h-I-S (stamped on left end)
Notes: Inscription (a) interpreted as in 56.5a; (b) as in 56.1b. The freehand mark (c) indicates a weight of 99 *librae*. No interpretation has been suggested for (d).

56.8) Lead ingot Veny 1969-70: 8; DOM 04.003.03
Type: D4.1
Metrics: l. 46.5 cm, w. 10 cm, h. 10.5 cm; m. 33.1 kg
Mold mark(s):
a) *palm* L·MANLI *palm* (AN in ligature; cartouche l. 19.5 cm, w. 2.5 cm)
Secondary Markings/Features:
b) IIII (freehand on rear face)
c) IMP·CAES (stamped three times on front face)
d) AVG (stamped on right end)
Notes: Inscription (a) is interpreted as *L(ucii) Manli(i)*. The *gens* Manlia is widely attested in the Roman world, with no particular ties to mining regions. For (c), see **56.1(b)**; for (d), see **56.2(d)**.

56.9) Lead ingot Veny 1969-70: 9; MAB inv. 17.179; DOM 04.003.01
Type: D4.1
Metrics: l. 41.2 - 46.5 cm, w. 10 cm, h. 9.5 cm; m: 32.25 kg
Mold mark(s):
a) *palm* L·MANLI *palm* (AN in ligature; cartouche l. 19.5 cm, w. 2.5 cm)
Secondary Markings/Features:
b) I (freehand on rear face)
c) VESP·AVG (stamped twice on front face)
d) AVG (stamped on left end)
Notes: Inscriptions (a) interpreted as in **56.8(a)**; (c) as in **56.5(c)**; (d) as in **56.2(d)**.

56.10) Lead ingot Veny 1969-70: 10; MAB inv. 17.180; DOM 04.003.02
Type: D4.1
Metrics: l. 41 - 45.5 cm, w. 11 cm, h. 9 cm; m. 32.25 kg
Mold mark(s):
a) *palm* L·MANLI *palm* (AN in ligature ; cartouche l. 21 cm, w. 2.5 cm)
Secondary Markings/Features:
b) IXXXXIX (freehand on front face)
c) VESP·AVG (stamped twice on front face, once on either side of (b))
Notes: Inscriptions (a) interpreted as in **56.8(a)**; (c) as in **56.5(c)**.

56.11) Lead ingot Veny 1969-70: 11; DOM 04.006.01
Type: D4.1
Metrics: l. 44 - 48 cm, w. 11 cm, h. 9 cm; m: 32 kg
Mold mark(s):
a) C·M·A *palm* (cartouche l. 17 cm, w. 2.2 cm)
Secondary Markings/Features:
b) IMP·CAES (stamped twice on rear face, second stamp inverted)

c) IXXXXIX (inverted, freehand on front face)
d) AVG (stamped twice on left end)
Notes: No name has been suggested for (a); all other stamps interpreted as in **56.2**.

56.12) Lead ingot Veny 1969-70: 12; DOM 04.005.01
Type: D4.1
Metrics: l. 43.5 - 47.3 cm, w. 10 cm, h. 9 cm; m. 32.25 kg
Mold Mark(s):
a) C·M·A *palm* (cartouche l. 20 cm, w. 2.3 cm)
Secondary Markings/Features:
b) VESP·AVG (stamped three times on rear face)
c) IXXXXIX (freehand on front face)
d) AVG (stamped on right end)
Notes: No name has been suggested for (a); all other stamps interpreted as **56.2**.

56.13) Lead ingot Veny 1969-70: 13; DOM 04.009.02
Type: D4.1
Metrics: l. 40 - 46 cm, w. 11 cm, h. 9 cm; m: 33.8 kg
Mold Mark(s):
a) SO *palm* * *rod* * *palm crown* * *dolphin* * *rod* VR *trident* (cartouche l. 19 cm, w. 2 cm)
Secondary Markings/Features:
b) VESP·AVG (stamped three times on rear face)
c) VI (freehand on front face)
d) AVG (stamped on right end)
Notes: No interpretation of (a) has been suggested; all other stamps interpreted as **56.2**.

56.14) Lead ingot Veny 1969-70: 14 DOM 04.009.01
Type: D4.1
Metrics: l. 46 cm, w. 11.5 cm, h. 9 cm; m. 33 kg
Mold Mark(s):
a) SO {*palm* * *rod* * *palm crown* * *dolphin* * *rod*} VR {*trident*} (cartouche l. 19 cm, w. 2 cm)
Secondary Markings/Features:
b) VESP·AVG (stamped three times on rear face)
c) IIII (freehand on front face)
Notes: No interpretation of (a) has been suggested; all other stamps interpreted as **56.2**.

56.15) Lead ingot Veny 1969-70: 15; DOM 04.010.01
Type: D4.1
Metrics: l. 46 cm, w. 11.2 cm, h. 9 cm; m. 32 kg
Mold Mark(s):
a) . . . . . X . (cartouche l. 18 cm, w. 2 cm)
Secondary Markings/Features:
b) IXXXXIX (freehand on rear face)
c) IMP·CAES (stamped twice on rear face)
d) AVG (stamped once on front face, once on right end)
Notes: Inscription (a) is too incomplete to restore. For (c), see **56.1(b)**; for (d), see **56.2(d)**.

56.16) Lead ingot Veny 1969-70: 16; MAB inv. 17.182; DOM 04.008.02
Type: D4.1
Metrics: l. 45 cm, w. 11.5 cm, h. 9.5 cm; m: 33.5 kg
Mold Mark(s):
a) Ạ·ṾỊṬỊ[756] *palm* (cartouche l. 17 cm, w. 2.5 cm)
Secondary Markings/Features:
b) IMP·CAES (stamped four times on rear face, some incomplete)
c) IIII (freehand on rear face, in center with two of (b) to each side)
d) AVG (stamped on left face)
Notes: No name has bee suggested for (a). For (c), see **56.1(b)**; for (d), see **56.2(d)**.

56.17) Lead ingot Veny 1969-70: 17; MAB inv 17.183; DOM 04.008.01
Type: D4.1
Metrics: l. 45 cm, w. 11.5 cm, h. 9.5 cm; m. 34 kg
Mold Mark(s):
a) Ạ·ṾỊṬỊ *palm* (cartouche l. 17 cm, w. 3 cm)
Secondary Markings/Features:

[756] These letters are proposed in Domergue and Liou 1997, Table 2.

b) VESP·AVG (inverted, stamped five times, some incomplete, with one overstrike)
c) V (inverted, freehand on front face)
d) AVG (stamped on left face)
Notes: Inscrption (a) is reconstructed as in 56.16(a). For (c), see 56.1(b); for (d), see 56.2(d).

56.18) Lead ingot DL 2**;** DOM 04.002.04
Type: D4.1
Metrics: m. 30.35 kg
Mold Mark(s):
a) Q·CORNVTI
Secondary Markings/Features:
b) IXXXXII (freehand)
Notes: Data reported only summarily. No information on dimensions or additional secondary marks was available. Inscription (a) interpreted as in **56.5(a)**.

56.19) Lead ingot DL 12; DOM 04.002.05
Type: D4.1
Metrics: m. 32.6 kg
Mold Mark(s):
a) Q·CORNVTI
Secondary Markings/Features:
b) IXXXXIX (freehand)
Notes: Data reported only summarily. No information on dimensions or additional secondary marks was available. Inscription (a) interpreted as in **56.5(a)**.

56.20) Lead ingot DL 13; DOM 04.004.04
Type: D4.1
Metrics: m. 32.65 kg
Mold Mark(s):
a) NE·MEVI·APRI (NE and ME in ligature)
Secondary Markings/Features:
b) IXXXXVIIII
Notes: Data reported only summarily. No information on dimensions or additional secondary marks was available. For inscription (a), see **56.2(a)**.

57) Sancti Petri
Alternate names: The Copper Wreck; Pecio del Cobre
Region: Andalucía *BA* 26:D5
Date: 65-80 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 18

Discussion: This cargo of copper and lead ingots was discovered just south of Cadiz in 1977. Twenty-eight copper "cake-shaped" ingots with no markings were recovered. Aside from a lead anchor stock, no other associated artifacts or hull remains were found. Based on the distribution of the ingots, the original ship length has been estimated at 27 m. The date of the wreck is primarily based on the ingot shapes which are comparable to those of the Ses Salines wreck (**56**). This site is in a sandy, high-energy environment, which may be responsible for the considerable erosion of the ingots and the subsequent variation among their weights and dimensions. This may also account for the lack of mold marks on the ingots, since the shapes of cartouches (averaging 23 cm x 3 cm) can be discerned.

Vallespin Gómez believes all the ingots were cast from a mold of 3 Roman *quadrantal*, approximately equivalent to 70 kg, although the ingots ranged from 32 to 66.5 kg. The higher weight range is primarily associated with Romano-British ingots, although not unprecedented in Spanish ingots (cf. 47, 48, and 51), while the ingot shape is most consistent with type D2, generally associated with Spanish production. Square holes in several of the ingots suggest possible nail holes similar to those found in ingots from the Sierra Morena range (cf. 36, 41, 45, 48). Due to the consistent placement of the holes in the base of the ingot and their depth of penentration, the excavators suggest these holes resulted from pouring the lead around a temporary handle in order to remove the ingot from the mold (cf. 62).

Identification numbers are from Vallespin Gómez 1986 (VG); no museum inventory numbers were provided.
Reference: Vallespin Gómez, 1986, Parker 1992a, 382.

57.1) Lead ingot 1/78
Type: D2
Metrics: l. 51 cm, w. 15 cm, h. 15 cm; m. 66.5 kg
Secondary Markings/Features: There is a round hole in one lateral face, and another (2 x 3 cm) in the base 3 cm from edge,

which appears to taper to a narrower dimension.

57.2) Lead ingot 2/78
Type: D2
Metrics: l. 51 cm, w. 12.3 cm, h. 14 cm; m. 56 kg
Secondary Markings/Features: A square hole (4 cm x 4 cm) penetrates 8 cm deep into base; another round hole on one side.

57.3) Lead ingot 3/78
Type: D2
Metrics: l. 51.3 cm, w. 13 cm, h. 11 cm; m. 50.5 kg
Secondary Markings/Features: none.

57.4) Lead ingot 4/78
Type: D2
Metrics: l. 52 cm, w. 14.3 cm, h. 15 cm; m. 61 kg
Mold Mark(s): Cartouche is faintly visible on back, but no stamp discernible.
Secondary Markings/Features:

57.5) Lead ingot 5/78
Type: D2
Metrics: l. 50 cm, w. 15 cm, h. 15 cm; m. 69 kg
Secondary Markings/Features: none.

57.6) Lead ingot 6/78
Type: D2
Metrics: l. 53.5 cm, w. 15.5 cm, h. 15 cm; m. 60.5 kg
Secondary Markings/Features: A square hole (4 x 4 cm) penetrates 9 cm into base.

57.7) Lead ingot 7/78
Type: D2
Metrics: l. 52 cm, w. 14 cm, h. 15 cm; m. 53 kg
Secondary Markings/Features: A square hole (4 cm x 4 cm) penetrates at least 5 cm near one of the vertices; hole depth was not fully known at time of publication due to sand and concretion.

57.8) Lead ingot 8/78
Type: D2
Metrics: l. 51 cm, w. 13 cm, h. 13 cm; m. not given
Secondary Markings/Features: Most eroded of the group; at the base near vertex, a square hole (4 x 4 cm) penetrates 8 cm deep.

57.9) Lead ingot 9/78
Type: D2
Metrics: l. 52 cm, w. 13.5 cm, h. 13 cm; m. 58.5 kg
Secondary Markings/Features: none.

57.10) Lead ingot 10/78
Type: D2
Metrics: l. 53 cm, w. 14.5 cm, h. 14 cm; m. 64.5 kg
Secondary Markings/Features: A square hole (4 x 4 cm) penetrates 9 cm into base.

57.11) Lead ingot 11/78
Type: D2
Metrics: l. 52 cm, w. 14 cm, h. 13 cm; m. 63 kg
Secondary Markings/Features:
a) …XVII (freehand(?) in right side of cartouche (l. 25 cm, w. 3 cm, depth 2 cm))
Notes: This ingot had minimal erosion, but the cartouche was partially covered by concretions, suggesting there is more of the inscription. The text could be a number or the end of a name in the genitive. The letter style is identified as a cursive script dated from the early first to sixth centuries C.E. It is unusual to find freehand marks in a cartouche, perhaps indicating the ingots were cast with blank cartouches that were marked after casting.

57.12) Lead ingot 12/78
Type: D2
Metrics: l. 53 cm, w. 13 cm, h. 14 cm; m. 62 kg
Secondary Markings/Features: none.

57.13) Lead ingot 13/78
Type: D2
Metrics: l. 55 cm, w. 10 cm, h. 15 cm; m. 55 kg
Secondary Markings/Features: none.

57.14) Lead ingot 1/79
Type: D2

Metrics: l. 51 cm, w. 15.5 cm, h. 14.5 cm; m. 53 kg
Secondary Markings/Features: none.

57.15) Lead ingot 2/79
Type: D2
Metrics: l. 52 cm, w. 15 cm, h. 14.5 cm; m. 42 kg
Secondary Markings/Features: none.
Notes: Results of chemical analysis show: 98.86% Pb, 0.11% Cu, 0.0135% Sb, 0.0051% As, 0.0045% Ag; Bi not reported. The testing method was not given. Based on comparison of these results with British ingots published in Tylecote,[757] Vallespin Gomez believes the lead has not yet been desilvered, and would have been so treated at its destination.

57.16) Lead ingot 3/79
Type: D2
Metrics: l. 52 cm, w. 15 cm, h. 15 cm; m. 53 kg
Secondary Markings/Features: none.

57.17) Lead ingot 4/79
Type: D2
Metrics: l. 51 cm, w. 15 cm, h. 14 cm; m. 37 kg
Secondary Markings/Features: none.
Notes: Results of chemical analysis results show: 99.59% Pb, 0.2642% Cu, 0.1120% Sb, 0.0186% As, 0.0046% Ag; Bi not reported. The testing method was not given. This also suggests a lack as desilvering, as in 57.15. A description of this ingot was not given, but its very low weight suggests heavy erosion.

57.18) Lead ingot 5/79
Type: D2
Metrics: l. 41.4 cm, w. 14.5 cm, h. 14 cm; m. 32.1 kg
Secondary Markings/Features: none.
Notes: A description of this ingot was not given, but its reduced length and very low weight suggest heavy erosion.

[757] Tylecote 1962.

58) Runcorn
Region: Cheshire *BA* 8:E1
Date: 84-96 C.E.
Cultural Affiliation: Romano-British
Number of Lead Ingots Found: 20 (2 recorded; none survive)
Discussion: This group of 20 ingots was discovered in the Mersey River of northwestern England ca. 1590.[758] Only the major inscriptions were recorded at the time, and all ingots are now lost. The ingots are assumed to have come from a shipwreck, although no additional cargo or hull remains can be firmly associated with the site. The initial date estimated is based on the fact that Domitian received the title Germanicus in 84 C.E (see 58.2). The fact that these ingots were found together with ingots produced nearly a decade prior suggests that ingots could remain in storage for some time either at the foundry or a secondary depot.
References: *RIB* 2404.33 and 2404.36 ; Parker 1992a, 371.

58.1) Several lead ingots *RIB* 2404.33
Type: D4
Metrics: (estimated based on correlates)[759] l. ca. 57 cm, w. ca. 14.5, h. 10 ca. cm; m. ca. 68 kg
Mold mark(s):
a) IMP·VESP·VII·T·IMP·V·COSS (back)
Notes: Inscription (a) is interpreted as *Imp(eratore) Vesp(asiano) VII T(ito) imp(eratore) V co(n)s(ulibus)* and translated as "(Cast) while the Emperor Vespasian was consul for the seventh time, and Titus, imperator, consul for the fifth time," which was 76 C.E.

[758] Parker (1992a, 371) gives a date of 1697, but I have accepted the date from *RIB*, 54.
[759] Two ingots with nearly the same inscription (lacking the final S) were found in Hints Common near Tamworth, Staffordshire (*RIB* 2404.34 and 2404.35). At least one of these ingots was also inscribed on the front face with DECEANG (reported as molded in the matrix but not in a cartouche).

58.2) Several lead ingots *RIB* 2404.36
Type: D4
Metrics: none recorded
Mold mark(s):
a) IMP·DOMIT·AVG·GER
Secondary Markings/Features:
b) DE CEANG (stamped or molded in front face)
Notes: Inscription (a) interpreted as *Imp(eratoris) Domit(iani) Aug(usti) Ger(manici)* and translated as "(Property) of the Emperor Domitian Augustus, conqueror of Germany." Inscription (b) is interpreted as *Deceang[l(icum)]* and is likely to refer to a tribe known from the region, between the Clwyd and Dee rivers, possibly the Decangi mentioned in Tacitus.[760]

59) Caesarea
Region: Haifa *BA* 69**:**A4
Date: 84-96 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 6
Discussion: Discovered in 1993 during excavation of the pozzolana blocks forming the Herodian harbor, these ingots represent the only contextually-documented imperial lead ingot find in the eastern Mediterranean.[761] They have been dated based on the mold marks referencing the emperor Domitian (see 58 for details). No cargo or hull remains surivived, although roughly a dozen fragments of lead sheathing along with some bronze or copper nails and two broken bolts were found nearby.

One ingot and two fragments of sheathing were subjected to lead isotope analysis, and are most consistent with an origin in the Eastern Rhodope Mountains, with samples matching the Madjarovo and Zvezdel mines in Bulgaria, and the Kirki and Essimi mines in Greece. A secondary stamp (**59.1b**) links the ingots to *municipium Dardanicum*, a mining center in Moesia Superior, west of the Rhodope mountains, suggesting final smelting may have taken some distance from the original mine.[762] Gold and silver mining in this region and in Dacia, directly to the north, may have helped focus infrastructural development in this area, facilitating lead production for eastern consumption. Raban suggests that since the sheathing and ingot originated together, the ingots were part of the ship's stores.

Six ingots were discovered, but two were so damaged by erosion that they were not published. The ingots appear to have been cast to a 200-*libra* (65.4 kg) standard, similar to ingots from Britain. The overall similarity of shape and inscription style with British ingots suggests strong ties to military mining engineers, possibly transferrred between the regions. The weight stamps are unusual here in that they are not freehand, but rather consist of a series of relief stamps of individual numbers or number groups strung together to indicate the full weight of the ingot, usually preceded by a relief stamp reading CAES.[763] At least two ingots have additional freehand weight marks, suggesting they were weighed again at another point in the distribution chain. Several ingots have circular holes in the base which may have come from casting the ingot around a stick or iron rod in order to lift it out of the mold once it has cooled (cf. **57**).
References: Raban 1999.

59.1) Lead ingot Raban 1999:1
Type: D4.2

[760] Tac. *Ann.* xii.32.
[761] See also **65** for lead ingots without documented context, recovered by fishermen from around Dor, Israel.
[762] Wilkes (1992, 258) believes this was located at modern Sočanica in Kosovo, which is over 600 km west of Madjarovo. An area in NW Asia Minor was also known as Dardania, but Raban (1999, 187) has ruled it out, even though it is located closer to a coastal route than the overland Moesian site. Further research into the logistics of Roman mining in this region could help decide this question.
[763] Separation between number stamps will be indicated by a / in the ingot entries.

Metrics: l. 54.9 cm, w. 14.6 cm, h. 10.3 cm; m. 60.8 kg.
Mold mark(s):
a) IMP·DOMIT·CAESARIS·AVG·GER (IT and AE in ligature; cartouche l. 46.8 cm, w. 4.4 cm)
b) MET DARD (inverted, in relief on rear face)
Secondary Markings/Features:
c) CLO (stamped on rear face)
d) SVBCGAL (relief stamped twice on rear face)[764]
e) CAES / X / X / CC / V / I / I (relief stamped on rear face)
f) P·T·R (relief stamped once on each end)
g) ÇXXXÇỊII (freehand on front face; second CI may also be read as a V)
h) NẸ..VE (N inverted; VE in ligature; stamped on front face)
Notes: Inscription (a) is interpreted as *Imp(eratoris) Domit(iani) Caesaris Aug(usti) Ger(manici)*, closely resembling those of **59.2**. The cartouche has small "handle" shapes at each end, sometimes called *tabula ansata*, which have also been recorded on some British ingots.[765] Inscription (b) is interpreted as *Met(alla) Dard(anica)*. Inscriptions (c) and (f) are believed to be merchant stamps, although if this was state-owned lead, this may not be the case. Raban suggests (d) be interpreted as "under the supervision of Gaius Calpurnius" (or *sub G(aio) Cal(purnio)*), perhaps an officer in charge of the foundry. The weight mark (e) comes to 187 *librae* or 61.15 kg. The freehand weight mark (g) can also be interpreted as 187 if the first number was actually a symbol representing 150.

59.2) Lead ingot Raban 1999:4
Type: D4.2
Metrics: l. 54.2 cm, w. 15.8 cm, h. 12.8 cm; m. 70.2 kg.
Mold mark(s):
a) IMP·DOMIT·CAESARIS·AVG·GER (IT and AE in ligature; cartouche l. 46.8 cm, w. 4.4 cm)
b) Ṃ DARD (inverted; in relief rear face)
Secondary Markings/Features:
c) CAES / CC / X / V (relief stamped on front face)
d) CLO (stamped on front face)
e) SVBÇ.. (relief stamped twice on front face; both incomplete)
f) .TR (relief stamped on left end; traces of a third on right end)
g) NẸḶ.. (stamped on front face)
h) HPIIXXIV (PH in ligature; freehand on front face)[766]
Notes: Circular hole in base. Inscriptions (a) and (b) are interpreted as in **59.1.** Weight stamp (c) comes to 215 *librae*, very close to the measured weight of 214.7 *librae.* Freehand mark (h) could not be reconciled to this weight.

59.3) Lead ingot Raban 1999:3
Type: D4.2
Metrics: l. 54.1 cm, w. 15.9 cm, h. 12.9 cm; m. 61.1 kg.
Mold mark(s):
a) IMP·DOMIT·CAESARIS·AVG·GER (IT and AE in ligature; cartouche l. 46.8 cm, w. 4.4 cm)
Secondary Markings/Features:
b) traces of three relief stamps for weights
Notes: Inscription (a) heavily worn and reconstructed based on 59.1 and 59.2; cartouche outline still visible. Circular hole in base near right end. Weight of ingot is 217 *librae* and the surviving weight stamps allow room for *CC / X / V* (215) or *CC / X / X* (220).

59.4) Lead ingot Raban 1999:4
Type: D4.2
Metrics: m. 54.7 kg.
Mold Mark(s):

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[764] The authors record this as two separate stamps, SVBCGAL and SCGA, but the latter appear to be partial version of the former, with a possible third strike leaving the initial S next to the C.
[765] See *RIB* 2404.17, 18, and 40.

[766] The letters were transcribed by Raban as HIXXIV but the sketch provided (Fig. 5) shows an extra vertical stroke before the first X and a distinct P-shaped loop coming from the top of the first vertical stroke of the H.

a) IMP·DOMIT·CAESARIS·AVG·GER (IT and AE in ligature; cartouche l. 46.8 cm, w. 4.4 cm (based on better preserved ingots))
Secondary Markings/Features:
b) CC (relief stamped)
Notes: This ingot was severely bent, making accurate measurement impossible. It is also heavily deteriorated, which may have lessened its weight. The surviving CC stamp indicates its original weight was close to 200 *libra*.

60) Saintes-Maries-de-la-Mer 1
Region: Bouches-du-Rhône *BA* 15:C3
Date: First century C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 100 (but 1 lost during recovery)
Discussion: Discovered in 1989, this site was identified primarily by its 100 lead ingots, roughly arranged in eight parallel lines on the sea floor. Fragments of amphorae were also found among the ingots, but the excavators could not determine if they were part of the cargo or part of the ship's stores. The area had been fished for many years prior to discovery, so it is possible that much material was lost. Examination of the ceramic fabric suggests a Baetican origin, as does one Dressel 20 amphora handle found there. The total weight of the ingots was nearly 5.5 tons, suggesting there was still room for an additional cargo of a more perishable nature.

Isotopic analysis of seven ingots shows that they did not originate from any of the known Spanish mines. Trincherini and colleagues note that the closest matching signatures come from the Cévennes range at the southern edge of the Massif Central in southern France, but Rothenhöfer argues for a better match with ores of the Sauerland region of Germany, a considerable distance east of the Rhine. This is important evidence for the expansion of lead exploitation in the face of the expanding European frontier and its increasing distance from Hispania. While the ingots' shapes are consistent with other output from Spain, the higher weight standard (140 *librae* for the D4 ingots; 120 for the D1 ingots) might be a distinctive feature of other Roman provinces or of military production.

Originally dated to the second half of the first century C.E., based on the Dressel 20 handle, the wreck may have come instead from the first decade of that century. If the Sauerland origin is correct, there was only a brief period, from 7 B.C.E to 9 C.E., when Roman forces were in control of the region.[767]
References: Long and Domergue 1995 (L&D2); Trincherini et al. 2001; Rothenhöfer 2003, Eck 2004.

60.1) Lead ingot L&D2 1.1; MAA inv. SM1.51-4279
Type: D4.2
Metrics: l. 50.8 cm, w. 11.5 cm, h. 11.4 cm; back l. 48.5 cm, w. 6.5 cm; m. 53.5 kg
Mold Mark(s):
a) [.] FLAVI *ivy* VERVCLAE *ivy* PLVMB <*ivy*> GERM *two roses*
Secondary Markings/Features:
b) IMP CAES (stamped with small cartouche on rear face)
c) XXIIII (freehand on right end)
Notes: First letter covered by a patch. Inscription (a) restored and interpreted as *[L] Flavi(i) Veruclae plumb(um) germ(anum)*, indicating lead produced in Germany by Lucius Flavius Verucla. Inscription (b) is interpreted as *Imp(eratoris) Caes(aris)*, suggesting the ingots were property of the state; similar secondary stamps were found on ingots from Ses Salines (**56**). Based on overstrikes, the IMP CAES stamps were applied last. Inscription (c) designated a weight of 24 *librae* over 140, which corresponds to its current weight.

60.2) Lead ingot L&D2 1.2; MAA inv. SM1.52-4280
Type: D4.2
Metrics: l. 50.8 cm, w. 11.5, h. 11.2; back l. 48.5, w. 6.0-6.5 cm; m. 52.6 kg
Mold Mark(s):

[767] Eck 2004, 21.

a) [.] FLAVI *ivy* VERVCLAE *ivy* PLVMB *ivy* GERM *two roses*
Secondary Markings/Features:
b) IMP[.]CAES (stamped with small cartouche on front face)
c) XXII (freehand on right end)
Notes: Last 6 characters in (a) are badly preserved. Inscriptions (a) and (b) interpreted as in 60.1. Inscription (c) indicates a weight of 22 *librae* over 140, although conversion of current weight comes to 21 *librae*.

60.3) Lead ingot L&D2 1.3; MAA inv. SM1.53-4281
Type: D4 Heavy
Metrics: l. 51.1 cm, w. 11.3 cm, h. 11.2 cm; back l. 48.5 cm, w. 6.2 cm; 52.4 kg
Mold Mark(s):
a) [.] FLAVI *ivy* VERVCLAE *ivy* PLVMB *ivy* GERM *two roses* [cartouche l. 45.7 cm]
Secondary Markings/Features:
b) IMP.CAE[.] (stamped with small cartouche twice on front face)
c) XX (freehand on right end)
Notes: Many letters of (a) partially obscured by patches of lead. Inscriptions (a) and (b) interpreted as in 60.1. Inscription (c) indicates a weight of 20 *librae* over 140, which corresponds to its current weight.

60.4) Lead ingot L&D2 1.4; MAA inv. SM1.54-4282
Type: D4.2
Metrics: l. 51.5 cm, w. 11.3 cm, h. 11.7 cm; back l. 48.4 cm, w. 7.0 cm; 52.4 kg
Mold Mark(s):
a) [……...]ERVLAE *ivy* PLVMB *ivy* GERM *two roses*
Secondary Markings/Features:
b) IMP.CAES (stamped with small cartouche twice on rear face)
c) XXII (freehand on left end)
Notes: Inscriptions (a) and (b) interpreted as in 60.1. Inscription (c) indicates a weight of 22 *librae* over 140, although conversion of current weight comes to 20 *librae*.

60.5) Lead ingot L&D2 1.5; MAA inv. SM1.55-4283
Type: D4.2
Metrics: l. 50.8 cm, w. 11.6 cm, h. 11.7-12.2 cm; back l. 47.8 cm, w. 7.0 cm; 55.0 kg
Mold Mark(s):
a) [.] FLAVI *ivy* VERVCLAE *ivy* PLVMB *ivy* GERM *two roses* [cartouche l. 45.2 cm]
Secondary Markings/Features:
b) IMP.CAES (stamped with small cartouche on rear face)
c) XX[..] (freehand on right end)
Notes: Inscriptions (a) and (b) interpreted as in 60.1. Inscription (c) is incomplete, but conversion of current weight suggests it should be restored as 28 *librae*.

60.6) Lead ingot L&D2 1.6; MAA inv. SM1.56-4284
Type: D4.2
Metrics: l. 50.9 cm, w. 11.3 cm, h. 11.8 cm; back l. 48.0 cm, w. 7.1; 55.0 kg
Mold Mark(s):
a) [.] FLAVI *ivy* VERVCLAE *ivy* PLVMB *ivy* GERM [..]
Secondary Markings/Features:
b) IMP.CAES (stamped with small cartouche on rear face)
c) XXIX (freehand on right end)
Notes: Final two characters of (a) are covered by patches of lead. Inscriptions (a) and (b) interpreted as in 60.1. Inscription (c) indicates a weight of 29 *librae* over 140, although conversion of current weight comes to 28 *librae.*

60.7) Lead ingot L&D2 1.7; MAA inv. SM1.57-4285
Type: D4.2
Metrics: l. 50.8 cm, w. 11.6 cm, h. 11.9 cm; back l. 48.4 cm, l. 6.5-7.0 cm; 54.6 kg
Mold Mark(s):
a) [.] F[.]AVI *ivy* VERCVLAE *ivy* PLVMB *ivy* GERM *two roses* [cartouche l. 45.7 cm]
Secondary Markings/Features:
b) IMP.CAES (stamped with small cartouche on front face)
Notes: Most of the letters in (a) are badly preserved. The border of the cartouche is heavily deformed. Inscriptions (a) and (b) interpreted as in 60.1. No weight mark was preserved on this ingot.

60.8) Lead ingot L&D2 1.8; MAA inv. SM1.58-4286

Type: D4.2

Metrics: l. 50.6-51.1 cm, w. 11.2 cm, h. 11.5 cm; back l. 48.1 cm, l. 6.8-7.0 cm; 54.8 kg

Mold Mark(s):

a) [.] F[.]AVI *ivy* VERCVLAE *ivy* PLVMB *ivy* GERM *ivy*

Secondary Markings/Features:

b) IMP […] (stamped with small cartouche on front face)

c) [?] XI[?] (freehand on right end)

Notes: Inscriptions (a) and (b) interpreted as in 60.1. Inscription (c) is incomplete, but conversion of current weight suggest a figure of 25 *librae;* original number was more likely 24 (XXIIII), based on the surviving *I*.

60.9 Lead ingot L&D2 2.1; MAA inv. SM1.1.4229

Type: D1.2

Metrics: l. 53.5-54 cm, w. 10.6-11.2 cm, h.11.0 cm; back l. 51.7 cm; m. 53.2 kg

Secondary Markings/Features:

a) L·FL·VERV (stamped on left end; VE and RV in ligature)

b) XLI (freehand on right end)

Notes: Inscription (a) interpreted as representing the same name attested in 60.1-8, with this stamp supplying the missing *praenomen* of Lucius. Based on overstrikes, these stamps were applied first. Inscription (c) indicates a weight of 41 *librae* over 120, although convervsion of current weight comes to 43 *librae*.

60.10 Lead ingot L&D2 2.2; MAA inv. SM1.2.4230

Type: D1.2

Metrics: l. 55.7 cm, w. 11 cm, h. 12 cm; back l. 51.2 cm; m. 58.25 / 59.2 kg[768]

Secondary Markings/Features:

a) IMP·CA[..] (relief stamped twice on back)

b) L·FL·VEṚṾ (stamped on left end; VE and RV in ligature)

c) [.]ROTIS (stamped on left end; S reversed)

d) LX (freehand on left end)

Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) interpreted as in 60.9(a). Inscription (c) restored as *Erotis*, genitive of the name Eros, possibly a slave, as it appears with alone. Based on overstrikes, these stamps, where occurring, were applied after the L.FL.VERV stamps, but before the IMP CAES stamps. Inscription (c) indicates a weight of 60 *librae* over 120, which is consistent with current weight.

60.11 Lead ingot L&D2 2.3; MAA inv. SM1.3.4231

Type: D1.2

Metrics: l. 53.5 cm, w. 11.1 cm, h. 11.3 cm; back l. 50.4 cm; m. 57 / 57.4 kg

Secondary Markings/Features:

a) ỊṂP […] (relief stamped on back)

b) LV (freehand on left end)

Notes: Inscription (a) interpreted as in 60.10(a).

60.12 Lead ingot L&D2 2.4; MAA inv. SM1.4.4232

Type: D1.2

Metrics: l. 55 cm, w. 10.8 cm, h. 11 cm; back l. 51.2 cm; m. 55.2 / 55.4 kg

Secondary Markings/Features:

a) [.]MP·CAES (relief stamped on front face)

b) L·FL·Ṿ[.] (stamped on left end)

c) IL (freehand on right end)

Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 49 *librae* over 120, which is consistent with current weight.

60.13 Lead ingot L&D2 2.5; MAA inv. SM1.5.4233

Type: D1.2

Metrics: l. 52.9 cm, w. 10.2 cm, h. 11.5 cm; back l. 49.5 cm; m. 49 / 48.6 kg

Secondary Markings/Features:

a) IMP·CAEṢ (stamped on back)

b) XXIX (freehand on left end)

[768] Some of the ingots were weighed twice, first with a standard balance, then with an electronic scale; where the results differed, both weights were reported.

Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 29 *librae* over 120, which is consistent with current weight.

60.14 Lead ingot L&D2 2.6; MAA inv. SM1.6.4234

Type: D1.2
Metrics: l. 53.1 cm, w. 11.1 cm, h. 11.3 cm; back l. 50.5 cm; m. 55 kg
Secondary Markings/Features:
a) ỊṂP·Ç[…] (relief stamped on back)
b) L·FL·Ṿ[.] (stamped on left end)
c) XLVII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a). Inscription (c) indicates a weight of 47 *librae* over 120, although conversion of modern weight corresponds to 48 *librae*.

60.15 Lead ingot L&D2 2.7; MAA inv. SM1.7.4235

Type: D1.2
Metrics: l. 53 cm, w. 10.1 cm, h. 11.3 cm; back l. 49.3 cm; m. 53.5 / 53.2 kg
Secondary Markings/Features:
a) L·FL·V[.] (stamped on left end)
b) LIIII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.9(a). Traces of an additional inscription (most likely L·FL·VE) can be seen on the back. Inscription (c) indicates a weight of 54 *librae*, which is consistent with current weight.

60.16 Lead ingot L&D2 2.8; MAA inv. SM1.8.4236

Type: D1.2
Metrics: l. 52 cm, w. 11.1 cm, h. 12.1 cm; back l. 48.8 cm; m. 57.4 / 57 kg
Secondary Markings/Features:
a) L·FL·VE (VE in ligature; stamped on left end)
b) LII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.9(a). Inscription (c) indicates a weight of 52 *librae* over 120, although conversion of modern weight comes to between 54 and 56 *librae*.

60.17 Lead ingot L&D2 2.9; MAA inv. SM1.9.4237

Type: D1.2
Metrics: l. 53.7-54.3 cm, w. 9.7 cm, h. 11.3-12.3 cm; back l. 50.5 cm; m. 52.4 / 52.6 kg
Secondary Markings/Features:
a) ỊMP̣·Ç[…] (relief stamped on front face)
b) L·FL·VEṚ[.] (stamped on left end)
c) XLI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a). Inscription (c) indicates a weight of 41 *librae* over 120, which is consistent with current weight.

60.18 Lead ingot L&D2 2.10; MAA inv. SM1.10.4238

Type: D1.2
Metrics: l. 51.8-52.4 cm, w. 10 cm, h. 11.8 cm; back l. 49.0 cm; m. 48 / 47.4 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped on front face)
b) [..]FL·VE (VE in ligature; stamped on right end)
c) XXIIX (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a). Inscription (c) indicates a weight of 28 *librae* over 120, although conversion of current weight comes to 25 and 27 *librae*.

60.19 Lead ingot L&D2 2.11; MAA inv. SM1.11.4239

Type: D1.2
Metrics: l. 52.7 cm, w. 10.3 cm, h. 10.8-12.5 cm; back l. 50.3 cm; m. 51.3 / 50.2 kg
Secondary Markings/Features:
a) IMP CAES (relief stamped on front face)
b) XXXIIII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 34 *librae* over 120, which is consistent with the lower of the two current weights.

60.20 Lead ingot L&D2 2.12; MAA inv. SM1.12.4240

Type: D1.2
Metrics: l. 52.7-53.3 cm, w. 10.9 cm, h. 11.7 cm; back l. 47.4 cm; m. 55.4 / 55.2 kg
Secondary Markings/Features:
a) IṂP̣ CAES (relief stamped twice on front face)

b) L (?) (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b). Concretions obscure the left end. Conversion of current weights comes to 48 or 49 *librae* over 120, suggesting (c) should be restored as *IIL* or *IL*.

60.21 Lead ingot L&D2 2.13; MAA inv. SM1.13.4241
Type: D1.2
Metrics: l. 56 cm, w. 11 cm, h. 9.5-11.3 cm; back l. 50.5 cm; m. 53 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped once on front face and once on base, both partially illegible)
b) L·FL·VER[.] (VE in ligature; stamped twice on left end)
c) ERO[…] (reversed; stamped on right end)
d) XLIII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (d) indicates a weight of 43 *librae* over 120, although conversion of current weight comes to 42.

60.22 Lead ingot L&D2 2.14; MAA inv. SM1.14.4242
Type: D1.2
Metrics: l. 53.2 cm, w. 10.4 cm, h. 12.1 cm; back l. 51.5 cm; m. 55 / 54.6 kg
Secondary Markings/Features:
a) IMP CAES (stamped twice on back)
b) L·FḶ·VE[..] (VE in ligature; stamped on left end)
c) XLVII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 47 *librae* over 120, which is consistent with current weight.

60.23 Lead ingot L&D2 2.15; MAA inv. SM1.15.4243
Type: D1.2
Metrics: l. 53.2 cm, w. 10.8 cm, h. 11.9 cm; back l. 40.8 cm; m. 54 / 53.4 kg
Secondary Markings/Features:
a) IMP·CAES (stamped on back)
b) [.....]VE (VE in ligature; stamped on right end)
c) XLV (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscripton (c) indicates a weight of 45 *librae* over 120, which is consistent with current weight.

60.24 Lead ingot L&D2 2.16; MAA inv. SM1.16.4244
Type: D1.2
Metrics: l. 53.1 cm, w. 10.5 cm, h. 11.4-11.9 cm; back l. 50.3; m. 54.5 / 54.4 kg
Secondary Markings/Features:
a) Ḷ·F̣L·VE (VE in ligature; stamped on left end)
b) XLVII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.9(a). Inscription (b) indicates a weight of 47 *librae* over 120, which is consistent with current weight.

60.25 Lead ingot L&D2 2.17; MAA inv. SM1.17.4245
Type: D1.2
Metrics: l. 53.7 cm, w. 10.6 cm, h. 11.7 cm; back l. 50.4; m. 56 / 55.4 kg
Secondary Markings/Features:
a) IMP·CAES (stamped on back)
b) L·FL·ṾẸṚ[.] (VE in ligature; stamped on right end)
c) [..]ỌṬỊṢ (S reversed; stamped on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). No weight mark was preserved on this ingot.

60.26 Lead ingot L&D2 2.18; MAA inv. SM1.18.4246
Type: D1.2
Metrics: l. 51 cm, w. 10.4-11 cm, h. 9.3-10.4 cm; back l. 46.2; m. 49.5 / 49.6 kg
Secondary Markings/Features:
a) [....]CAES (relief stamped on front face)
Notes: Inscription (a) interpreted as in 60.1(b). No weight mark was preserved on this ingot.

60.27 Lead ingot L&D2 2.19; MAA inv. SM1.19.4247
Type: D1.2
Metrics: l. 52.6 cm, w. 10.4 cm, h. 11.1 cm; back l. 50.5 cm; m. 52.5 / 52.2 kg
Secondary Markings/Features:

a) IMP·CA[..] (relief stamped twice on front face, one very incomplete)
b) [..]FL·VE (stamped on left end)
c) XLII (freehand on left end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 42 *librae* over 120, although conversion of current weights comes to 40 or 41 *librae*.

60.28 Lead ingot L&D2 2.20; MAA inv. SM1.20.4248
<u>Type</u>: D1.2
<u>Metrics</u>: l. 53-53.5 cm, w. 10.5 cm, h. 10.9-11.6 cm; back l. 50.2 cm; m. 52 / 51.6 kg
<u>Secondary Markings/Features</u>:
a) ỊṂP̣ C̣ẠẸṢ (relief stamped twice on back, one very incomplete)
b) L·FL·VE (VE in ligature; stamped on left end)
c) XL (freehand on right end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 40 *librae* over 120, although conversion of current weight comes to 38 or 39 *librae*.

60.29 Lead ingot L&D2 2.21; MAA inv. SM1.21.4249
<u>Type</u>: D1.2
<u>Metrics</u>: l. 52.2-53 cm, w. 10.1-10.6 cm, h. 10.9 cm; back l. 47.2 cm; m. 53 / 52.8 kg
<u>Secondary Markings/Features</u>:
a) ỊṂ[...]ẠẸ[.] (stamped on back)
b) [..]FL·VERV (VE and RV in ligature; stamped on right end)
c) XLIIII (stamped on right end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(a); and (b) as in 60.9(a). Inscription (c) indicates a weight of 44 *librae* over 120, although conversion of current weights comes 41 or 42 *librae*. A modern 'E' is inscribed on the base.

60.30 Lead ingot L&D2 2.22; MAA inv. SM1.22.4250
<u>Type</u>: D1.2
<u>Metrics</u>: l. 52.5-53 cm, w. 10.8-11.4 cm, h. 12 cm; back l. 51.0 cm; m. 58 / 57.8 kg
<u>Secondary Markings/Features</u>:
a) ỊṂP̣·C̣ẠẸṢ (stamped twice on back, one incomplete)
b) Ḷ·FḶ·ṾẸ (VE in ligature; stamped on left end)
c) LIX (freehand on left end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 59 *librae* over 120, although conversion of current weight comes to 57 *librae*. A modern '4' is inscribed on the base.

60.31 Lead ingot L&D2 2.23; MAA inv. SM1.23.4251
<u>Type</u>: D1.2
<u>Metrics</u>: l. 52.4 cm, w. 10-10.9 cm, h. 10.8 cm; back l. 50.0 cm; m. 50.5 / 50.2 kg
<u>Secondary Markings/Features</u>:
a) IMP CAES (relief stamped on front face)
b) [...]Ḷ·ṾẸ (stamped on left end)
c) XX[...] (stamped on left end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) is incomplete, but conversion of current weight suggests it should be restored as 33 (*XXXIII*) or 34 (*XXXIIII*). A modern 'D' is inscribed on the base.

60.32 Lead ingot L&D2 2.24; MAA inv. SM1.24.4252
<u>Type</u>: D1.2
<u>Metrics</u>: l. 51.9 cm, w. 10.7 cm, h. 11.3 cm; back l. 50.3 cm; m. 54 / 53.6 kg
<u>Secondary Markings/Features</u>:
a) IMP·CAES (relief stamped on back)
b) L·FL·VE (stamped on right end)
c) XLIIII (freehand on left end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 44 *librae* over 120, which is consistent with current weight.

60.33 Lead ingot L&D2 2.25; MAA inv. SM1.25.4253
<u>Type</u>: D1.2
<u>Metrics</u>: l. 53.6 cm, w. 10.3 cm, h. 12 cm; back l. 49.4 cm; m. 50 / 50.6 kg
<u>Secondary Markings/Features</u>:
a) IMP C[...] (relief stamped twice on back)
b) XLII (freehand on right end)
<u>Notes</u>: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 42 *librae* over 120, although

conversion of current weight comes to between 33 and 35 *librae*.

60.34 Lead ingot L&D2 2.26; MAA inv. SM1.26.4254

Type: D1.2
Metrics: l. 55.7 cm, w. 11.7 cm, h. 11.7-12.3 cm; back l. 47.2; m. 62 / 61.8 kg
Secondary Markings/Features:
a) IMP·CAES (stamped on back)
b) L·FL·VE[..] (VE in ligature; stamped on left end)
c) EROTI[.] (reversed; stamped on left end)
d) LXXI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (c) indicates a weight of 71 *librae* over 120, although conversion of current weights comes to 69 or 70 *librae*.

60.35 Lead ingot L&D2 2.27; MAA inv. SM1.27.4255

Type: D1.2
Metrics: l. 53.4 cm, w. 10.8 cm, h. 11.9 cm; back l. 50.5 cm; m. 54.9 / 54.4 kg
Secondary Markings/Features:
a) [.]ṂP̣·CAES (relief stamped on front face)
b) [.....]VE (VE in ligature; stamped on right end)
c) XLVII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 47 *librae* over 120, which is consistent with current weight.

60.36 Lead ingot L&D2 2.28; MAA inv. SM1.28.4256

Type: D1.2
Metrics: l. 53-54 cm, w. 10.5-11.2 cm, h. 9.9-12.1 cm; back l. 50.5; m. 52 kg
Secondary Markings/Features:
a) [.]ṂP̣ CAẸṢ (stamped on front face)
b) XL (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 40 *librae* over 120, although conversion of current weight indicates a figure of 39.

60.37 Lead ingot L&D2 2.29; MAA inv. SM1.29.4257

Type: D1.2
Metrics: l. 53.4 cm, w. 10.1 cm, h. 12.5 cm; back l. 49.7 cm; m. 55.7 / 55.2 kg
Secondary Markings/Features:
a) IMP·CAES (stamped on back)
b) LI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 51 *librae* over 120, although conversion of current weight comes to 49 or 50 *librae*.

60.38 Lead ingot L&D2 2.30; MAA inv. SM1.30.4258

Type: D1.2
Metrics: l. 52 cm, w. 11 cm, h. 11.9-12.4 cm; back l. 49.5 cm; m. 59 / 59.4 kg
Secondary Markings/Features:
a) ỊṂP̣ C̣ẠẸṢ (relief stamped on front face, with traced of a second with no legible letters)
b) L·FL·VE[..] (VE in ligature; stamped on right end)
c) LXI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 61 *librae* over 120, which is consistent with current weight. A vertical line, perhaps from the tip of chisel, is found in the left end.

60.39 Lead ingot L&D2 2.31; MAA inv. SM1.31.4259

Type: D1.2
Metrics: l. 52.7 cm, w. 10.7 cm, h. 10.3-10.9 cm; back l. 49.8 cm; m. 50.8 / 50.2 kg
Secondary Markings/Features:
a) IMP C̣ẠẸṢ (stamped on front face)
b) XXXIIII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (c) indicates a weight of 34 *librae* over 120, which is consistent with current weight.

60.40 Lead ingot L&D2 2.32; MAA inv. SM1.32.4260

Type: D1.2
Metrics: l. 53.3 cm, w. 10 cm, h. 11.1 cm; back l. 50.3 cm; m. 50.5 / 50.8 kg
Secondary Markings/Features:

a) IMP CAES (stamped on back)
b) [..]F̣Ḷ·VE (VE in ligature; stamped on right end)
c) [.]XXV
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) is not complete, but conversion of current weight suggests it should be restored as 35 (*XXXV*). There is a deep vertical incision in the left end, deeper and wider at the botton, likely from a tool blade.

60.41 Lead ingot L&D2 2.33; MAA inv. SM1.33.4261
Type: D1.2
Metrics: l. 53.2 cm, w. 10.6 cm, h. 12.2 cm; back l. 49.7 cm; m. 60 / 59.8 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped twice on back)
b) L·F̣Ḷ·Ṿ[.?] (stamped on left end)
c) LXVI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 66 *librae* over 120, although conversion of current weights comes to 63 *librae*.

60.42 Lead ingot L&D2 2.34; MAA inv. SM1.34.4262
Type: D1.2
Metrics: l. 54-54.5 cm, w. 10.6-11 cm, h. 11.1-12.5 cm; back l. 52.5; m. 56 kg
Secondary Markings/Features:
a) ỊMP̣·C̣ẠẸṢ (stamped on front face)
Notes: Inscription (a) interpreted as in 60.1(b). Nothing else is visible on the ingot.

60.43 Lead ingot L&D2 2.35; MAA inv. SM1.35.4263
Type: D1.2
Metrics: l. 53-53.5 cm, w. 11 cm, h. 11.1-11.9 cm; back l. 47.5 cm; m. 54 kg
Secondary Markings/Features:
a) ỊṂP̣·C̣ẠẸṢ (stamped on back)
b) EROTI[.] (letters reversed; stamped twice on front face, twice on left end, twice on right face; all stamps only partially complete)
c) Ḷ·FL[…] (stamped twice on left end)
d) XLIIX (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.10(c); and (c) as in 60.9(a). Inscription (c) indicates a weight of 48 *librae* over 120, although conversion of current weight comes to 45 *librae*.

60.44 Lead ingot L&D2 2.36; MAA inv. SM1.36.4264
Type: D1.2
Metrics: l. 53.4 cm, w. 10.6 cm, h. 11.9-12.9 cm; back l. 51 cm; m. 61 kg
Secondary Markings/Features:
a) IMP·C̣ẠẸṢ (stamped once on front face, once on rear face)
b) ERO[…..] (stamped on left end)
c) L·FL·VE (VE in ligature; stamped on right end)
d) LXVI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.10(c); and (c) as in 60.9(a). Inscription (c) indicates a weight of 66 *librae* over 120, although conversion of current weight comes to 47 *librae*.

60.45 Lead ingot L&D2 2.37; MAA inv. SM1.37.4265
Type: D1.2
Metrics: l. 55.3 cm, w. 10.2 cm, h. 11-12 cm; back l. 49.3 cm; m. 50 / 49.8 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped on base)
b) [.]·F̣Ḷ ṾẸ (VE in ligature; stamped on left end)
c) XXXI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 31 *librae* over 120, although conversion current weight comes to 32 or 33 *librae*.

60.46 Lead ingot L&D2 2.38; MAA inv. SM1.38.4266
Type: D1.2
Metrics: l. 52.5 cm, w. 10-10.5 cm, h. 11.4-12 cm; back l. 50 cm; m. 53 / 52.8 kg
Secondary Markings/Features:
a) IMP·CAES (stamped on front face)
b) XLIII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (c) indicates a weight of 43 *librae* over 120, although

conversion of current weight comes to 41 or 42 *librae*.

60.47 Lead ingot L&D2 2.39; MAA inv. SM1.39.4267

Type: D1.2
Metrics: l. 57.5 cm, w. 11.2-11.8 cm, h. 13 cm; back l. 47.5 cm; m. 68 / 68.2 kg
Secondary Markings/Features:
a) ỊṂP·CAES (stamped on back)
b) L·FL·VERṾ (VE and RV in ligature; stamped on left end)
c) ẸṚOTIS (S reversed; stamped twice on right end, both incomplete)
d) LXXXIIX (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (d) indicates a weight of 88 *librae* over 120, which is consistent with current weight.

60.48 Lead ingot L&D2 2.40; MAA inv. SM1.40.4268

Type: D1.2
Metrics: l. 52.5 cm, w. 10.4-10.9 cm, h. 10-11.1 cm; back l. 50.3 cm; m. 51 / 50.4 kg
Secondary Markings/Features:
a) ỊṂP·ÇẠẸṢ (stamped on front face)
b) XXXV (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 35 *librae* over 120, which is consistent with current weight.

60.49 Lead ingot L&D2 2.41; MAA inv. SM1.41.4269

Type: D1.2
Metrics: l. 52.8-53.5 cm, w. 10.4 cm, h. 11.8 cm; back l. 50.1 cm; m. 56.8 / 56.6 kg
Secondary Markings/Features:
a) [….]CAES (relief stamped on front face)
b) Ḷ·FL·VE (VE in ligature; stamped on left end)
c)[.]ṚỌ[…] (stamped on right end)
d) LVI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (c) indicates a weight of 56 *librae* over 120, although conversion of current weights come to 53 or 54 *librae*.

60.50 Lead ingot L&D2 2.42; MAA inv. SM1.42.4270

Type: D1.2
Metrics: l. 54.4 cm, w. 10 cm, h. 11.8-12.5 cm; back l. 51 cm; m. 59 kg
Secondary Markings/Features:
a) ỊṂP·ÇẠẸṢ (stamped on front face)
b) L·FL·VERV (VE and RV in ligature; ṣtamped on left end)
c) [..]ỌTIṢ (letters in reverse order; stamped on left end)
d) LXI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (d) indicates a weight of 61 *librae* over 120, although conversion of current weight comes to 50 *librae*.

60.51 Lead ingot L&D2 2.43; MAA inv. SM1.43.4271

Type: D1.2
Metrics: l. 53.5 cm, w. 11.2 cm, h. 11.8-12.8 cm; back l. 50.2 cm; m. 56 kg
Secondary Markings/Features:
a) ỊṂP ÇẠẸṢ (stamped on back)
b) L·FL V[.] (stamped twice on left end)
c) LI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a). Inscription (c) indicates a weight of 51 librae over 120, which is consistent with current weight.

60.52 Lead ingot L&D2 2.44; MAA inv. SM1.44.4272

Type: D1.2
Metrics: l. 52.4 cm, w. 10.9 cm, h. 11.7 cm; back l. 50.3 cm; m. 56 kg
Secondary Markings/Features:
a) [.]M[……] (stamped on back)
b) LIII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (c) indicates a weight of 53 *librae* over 120, although conversion of current weight comes to 51 *librae*. Possible traces of an additional stamp on the left end.

60.53 Lead ingot L&D2 2.45; MAA inv. SM1.45.4273

Type: D1.2
Metrics: l. 53 cm, w. 10.3-10.7 cm, h. 10.6-11.8 cm; back l. 49.8 cm; m. 51.5 kg

Secondary Markings/Features:
a) ỊṂP̣ C̣ẠẸṢ (stamped on back)
b) [.]ROTIS (letters in reverse order and all letters reversed except S).
c) [.]XX[.](?) (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.10(c). Inscription (c) is incomplete, but conversion of current weight comes to 37 *librae* for a possible restoration of [*X*]*XX*[*VII*].

60.54 Lead ingot L&D2 2.46; MAA inv. SM1.46.4274
Type: D1.2
Metrics: l. 53-53.5 cm, w. 10.4-11.2 cm, h. 10.9-11.8 cm; back l. 50.0 cm; m. 53.8 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped on back)
b) [.]OTIS (S reversed; stamped on right end)
c) Ḷ·P̣Ḷ·ṾẸ (VE in ligature; stamped on left end)
d) XLIIII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.10(c); and (c) as in 60.9(a). Inscription (d) indicates a weight of 44 *librae* over 120, although conversion of current weight comes to 45 *librae*.

60.55 Lead ingot L&D2 2.47; MAA inv. SM1.47.4275
Type: D1.2
Metrics: l. 52.3 cm, w. 11 cm, h. 12.1 cm; back l. 50.0 cm; m. 54.5 kg
Secondary Markings/Features:
a) ỊṂP̣·C̣ẠẸṢ (stamped once on base, and once, incomplete, on front face)
b) L·FL·VE (VE in ligature; stamped on left end)
c) XLVII (stamped on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 47 *librae* over 120, which is consistent with current weight.

60.56 Lead ingot L&D2 2.48; MAA inv. SM1.48.4276
Type: D1.2
Metrics: l. 56.2 cm, w. 10.9-11.8, h. 12.7 cm; back l. 51.4 cm; m. 63.2 / 64 kg
Secondary Markings/Features:
a) IMP C̣ẠẸṢ (stamped on front face)
b) [.]ṚỌṬỊṢ (letters in reverse order and all letters reversed except S; stamped on left end)
c) L·FL·VERV (VE and RV in ligature; stamped on left end)
d) LXXVI (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.10(c); and (c) as in 60.9(a). Inscription (d) indicates a weight of 76 *librae* over 120, which is consistent with current weight.

60.57 Lead ingot L&D2 2.49; MAA inv. SM1.49.4277
Type: D1.2
Metrics: l. 53.5 cm, w. 10.3 cm, h. 11.1-12.3 cm; back l. 49.9 cm; m. 55.1 / 55.2 kg
Secondary Markings/Features:
a) ỊṂP̣ C̣ẠẸṢ (relief stamped on front face)
b) XLIIX (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 48 *librae* over 120, although conversion of current weight comes to 49 *librae*.

60.58 Lead ingot L&D2 2.50; MAA inv. SM1.50.4278
Type: D1.2
Metrics: l. 53.4 cm, w. 10.2-11 cm, h. 11.2 cm; back l. 49.9 cm; m. 55.6 / 57.2 kg
Secondary Markings/Features:
a) ỊṂP̣ CAES (relief stamped three times on front face)
b) L·FL·VE (VE in ligature; stamped on left end)
c) LIIII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 54 *librae* over 120, which is consistent with current weight.

60.59 Lead ingot L&D2 2.51; MAA inv. SM1.59.4287
Type: D1.2
Metrics: l. 53.5 cm, w. 10.3 cm, h. 12 cm; back l. 49.7 cm; m. 51 / 51.4 kg
Secondary Markings/Features:
a) IMP CAES (stamped on back)
b) L·FL·V[.?] (stamped on right end)

c) XXXIX (freehand twice on left end, once reversed)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 39 *librae* over 120, although conversion of current weights comes to 36 or 37 *librae*. This ingot demonstrates noticeable separation of layers, indicating it was cast using multiple pours.

60.60 Lead ingot L&D2 2.52; MAA inv. SM1.60.4288
Type: D1.2
Metrics: l. 52.7 cm, w. 10.7 cm, h. 11-12.3 cm; back l. 50.4 cm; m. 55.3 / 55.4 kg
Secondary Markings/Features:
a) IMP Ç[…] (stamped five times, all incomplete, on back)
b) [..] FL·VE (VE in ligature; stamped on left end)
c) L (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 50 *librae* over 120, although conversion of current weight comes 49 *librae*.

60.61 Lead ingot L&D2 2.53; MAA inv. SM1.61.4289
Type: D1.2
Metrics: l. 53.1 cm, w. 11 cm, h. 11.2-11.9 cm; back l. 49.8 cm; m. 51.8 kg
Secondary Markings/Features:
a) ỊṂP̣ ÇẠẸṢ (stamped on front face)
b) [.].FL·VE (VE in ligature; stamped on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). No weight inscription was preserved on this ingot.

60.62 Lead ingot L&D2 2.54; MAA inv. SM1.62.4290
Type: D1.2
Metrics: l. 52.9 cm, w. 10.4 cm, h. 11.3 cm; back l. 50.3 cm; m. 52 / 51.8 kg
Secondary Markings/Features:
a) IMP CAES (relief stamped on front face)
b) L·FL·V[.] (stamped on right end)
c) EṚỌT[..] (stamped on left end)
d) XXXIX (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (d) indicates a weight of 39 *librae* over 120, which is consistent with current weight.

60.63 Lead ingot L&D2 2.55; MAA inv. SM1.63.4291
Type: D1.2
Metrics: l. 51.7 cm, w. 10.3 cm, h. 11.6 cm; back l. 50.1 cm; m. 53 / 53.2 kg
Secondary Markings/Features:
a) IMP·CAẸṢ (stamped on back)
b) Ḷ·F̣Ḷ[…] (stamped on right end)
c) XLV (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Stamp (b) heavily concreted. Inscription (c) indicates a weight of 45 *librae* over 120, although conversion of current weight comes to 42 or 43 *librae*.

60.64 Lead ingot L&D2 2.56; MAA inv. SM1.64.4292
Type: D1.2
Metrics: l. 52.8 cm, w. 10.6 cm, h. 10.9-12 cm; back l. 50.5 cm; m. 52 / 52.4 kg
Secondary Markings/Features:
a) [….]ÇẠẸṢ (stamped on front face)
b) [..]F̣L·VE (stamped on right end)
c) [.]LI (freehand on left end)
d) XL (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). It appears the first attempt at the number was abandoned incomplete (d) and it was rewritten lower down in full (c). The numerals letters combine to form 41 (*XLI*) *librae* over 120, and conversion of current weight comes to 40 *librae*.

60.65 Lead ingot L&D2 2.57; MAA inv. SM1.65.4293
Type: D1.2
Metrics: l. 53.5 cm, w. 10.7 cm, h. 12.2 cm; back l. 50.9 cm; m. 59 / 59.4 kg
Secondary Markings/Features:
a) ỊṂP̣·ÇẠẸṢ (stamped on back)
b) L·FḶ[…] (stamped on right end)
c) LXII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 62 *librae* over

120, which is consistent with current weight. There is a small swelling between the X and I in (c), over which (b) was partially stamped.

60.66 Lead ingot L&D2 2.58; MAA inv. SM1.66.4294

Type: D1.2
Metrics: l. 52.8 cm, w. 9.9-10.4 cm, h. 11.7 cm; back l. 51.2 cm; m. 54 kg
Secondary Markings/Features:
a) IMP̣·C̣AES (relief stamped on front face)
b) [..]F̣L·VE (VE in ligature; stamped on left end)
c) XLV (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 45 *librae* over 120, although conversion of current weights comes to between 51 and 53 *librae*.

60.67 Lead ingot L&D2 2.59; MAA inv. SM1.67.4295

Type: D1.2
Metrics: l. 53.6 cm, w. 9.7 cm, h. 11.5-12.4 cm; back l. 50.2 cm; m. 53.5 / 53.4 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped twice on front face)
b) […..]VE (VE in ligature; stamped on left end)
c) XLIIII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Insciption (c) indicates a weight of 44 *librae* over 120, although conversion of current weight comes to 63 or 64 *librae*.

60.68 Lead ingot L&D2 2.60; MAA inv. SM1.68.4296

Type: D1.2
Metrics: l 53 cm, w. 10.4 cm, h. 11.6 cm; back l. 50 cm; m. 51.8 / 51.6 kg
Secondary Markings/Features:
a) ỊṂP̣ C̣ẠẸṢ (stamped on back)
b) L·FL·Ṿ[.] (stamped on right end)
c) XX[…] (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) is incomplete, but conversion of current weight comes to 38 (*XXXVIII*) *librae* over 120.

60.69 Lead ingot L&D2 2.61; MAA inv. SM1.69.4297

Type: D1.2
Metrics: l. 53.5-54 cm, w. 9.9-10.4 cm, h. 10-11.9 cm; back l. 50.1 cm; m. 50 kg
Secondary Markings/Features:
a) IMP·CAES (stamped on back)
b) XXXI[.] (freehand on front face)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) is incomplete, but conversion of current weight comes to 33 (*XXXIII*) *librae* over 120.

60.70 Lead ingot L&D2 2.62; MAA inv. SM1.70.4298

Type: D1.2
Metrics: l. 53.2 cm, w. 10.1 cm, h. 10.7-11.3 cm; back l. 49 cm; m. 50.5 / 50.4 cm
Secondary Markings/Features:
a) IMP·CAES (relief stamped on back)
b) Ḷ·F̣Ḷ·ṾẸ (VE in ligature; stamped on left end)
c) XXXV (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 35 *librae* over 120, although conversion of current weight comes to 34 *librae*.

60.71 Lead ingot L&D2 2.63; MAA inv. SM1.71.4299

Type: D1.2
Metrics: l. 51.4-52.2 cm, w. 10 cm, h. 11.6 cm; back l. 48.7 cm; m. 48 / 47.8 kg
Secondary Markings/Features:
a) [..]ṂP̣·CAES (relief stamped on front face)
b) L·FL·VE (stamped on right end)
c) XXIIX (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 28 *librae* over 120, although conversion of current weight comes to 27 *librae*.

60.72 Lead ingot L&D2 2.64; MAA inv. SM1.72.4300

Type: D1.2
Metrics: l. 53.2 cm, w. 11.2 cm, h. 12.4 cm; back l. 50.1 cm; m. 59.5 / 60.6 kg

Secondary Markings/Features:
a) IMP·CAES (relief stamped three times on front face)
b) L·FL·VE (VE in ligature; stamped on left end)
c) LXVI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 66 *librae* over 120, although conversion of current weight comes to between 62 and 65 *librae*.

60.73 Lead ingot L&D2 2.65; MAA inv. SM1.73.4301
Type: D1.2
Metrics: l. 54 cm, w. 10.6-11.4 cm, h. 12.1 cm; back l. 51.1 cm; m. 56.5 / 56.8 kg
Secondary Markings/Features:
a) IMP·CAES (relief stamped twice on front face)
b) Ḷ·F̣Ḷ·VE (stamped once on left end, once on right end)
c) LIIII (stamped on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 54 *librae* over 120, which is consistent with current weight.

60.74 Lead ingot L&D2 2.66; MAA inv. SM1.74.4302
Type: D1.2
Metrics: l. 54.6 cm, w. 10.4-11.2 cm, h. 12.3 cm; back l. 50.7 cm; m. 56 / 56.6 kg
Secondary Markings/Features:
a) [….]C̣ẠẸṢ (stamped on back)
b) [..]FL·VE (VE in ligature; stamped on right end)
c) XLV (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 45 *librae* over 120, although conversion of current weight comes to between 51 and 53 *librae*.

60.75 Lead ingot L&D2 2.67; MAA inv. SM1.75.4303
Type: D1.2
Metrics: l 55.9 cm, w. 10.8 cm, h. 10.7-11.3 cm; back l. 51.1 cm; m. 55.5 / 55.2 kg
Secondary Markings/Features:
a) IMP CAES (relief stamped twice on front face)
b) L·FL·VER[.] (stamped on left end)
c) [..]ỌTIS (letters in reverse order; stamped twice on left end)
d) XLX (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.9(a); and (c) as in 60.10(c). Inscription (d) indicates a weight a of 50 *librae* over 120, which is consistent with current weight.

60.76 Lead ingot L&D2 2.68; MAA inv. SM1.76.4304
Type: D1.2
Metrics: l. 54-54.5 cm, w. 11.3 cm, h. 8.9 cm; back l. 51.2 cm; m. 46.8 / 46.6 kg
Secondary Markings/Features:
a) [Ị…….] (relief stamped on base)
b) L·FL·VE[..] (stamped on left end)
c) XXII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 22 *librae* over 120, which is consistent with current weight.

60.77 Lead ingot L&D2 2.69; MAA inv. SM1.77.4305
Type: D1.2
Metrics: l. 54.3 cm, w. 10.7-11.4 cm, h. 12.1-12.9 cm; back l. 51.7 cm; m. 63 / 63.2 kg
Secondary Markings/Features:
a) IMP C̣A[..] (relief stamped on back)
b) L·FL·VE (VE in ligature; stamped on right end)
c) LXXIII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 73 *librae* over 120, which is consistent with current weight.

60.78 Lead ingot L&D2 2.70; MAA inv. SM1.78.4306
Type: D1.2
Metrics: l. 52.4 cm, w. 10.2 cm, h. 11.1-12 cm; back l. 49 cm; m. 50.8 / 50.6 kg
Secondary Markings/Features:
a) IMP·CA[..] (relief stamped on front face)

b) L·FL·ṾẸ (VE in ligature; stamped on right end)
c) XXXIV (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 34 *librae* over 120, although conversion of current weight comes to 35 *librae*.

60.79 Lead ingot L&D2 2.71; MAA inv. SM1.79.4307
Type: D1.2
Metrics: l. 53 cm, w. 9.9 cm, h. 11.7 cm; back l. 49.1 cm; m. 52.5 / 53 kg
Secondary Markings/Features:
a) IMP·CAE[.] (relief stamped on front face)
b) L·FḶ·VẸ (VE in ligature; stamped on left end)
c) XLIII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (c) as in 60.9(a). Inscription (c) indicates a weight of 43 *librae* over 120, although conversion of current weight comes to between 40 and 42 *librae*.

60.80 Lead ingot L&D2 2.72; MAA inv. SM1.80.4308
Type: D1.2
Metrics: l. 53.7 cm, w. 10.7 cm, h. 11.9 cm; back l. 50.7 cm; m. 55.3 / 55.6 kg
Secondary Markings/Features:
a) [..]FL·VE (stamped on left end)
b) LI (freehand on right cend)
Notes: Inscription (a) interpreted as in 60.9(a). Inscription (b) indicates a weight of 51 *librae* over 120, although conversion of current weights comes to 49 or 50 *librae*. Traces of a relief stamp on front face, no longer legible.

60.81 Lead ingot L&D2 2.73; MAA inv. SM1.81.4309
Type: D1.2
Metrics: l. 53.7 cm, w. 9.8 cm, h. 11.6 cm; back l. 50 cm; m. 50.9 / 51.6 kg
Secondary Markings/Features:
a) IṂP̣·Ç̣AẸ[.] (stamped on back)
b) [..]FL·VERV (VE and RV in ligature; stamped three times on right end)
c) Ḷ·F̣Ḷ[..] (stamped on right end)
d) LX (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) and (c) as in 60.9(a). One instance of (b) is struck over another. Inscription (d) indicates a weight of 60 *librae* over 120, although conversion of current weights comes to 36 or 37 *librae*.

60.82 Lead ingot L&D2 2.74; MAA inv. SM1.82.4310
Type: D1.2
Metrics: l. 53 cm, w. 10.2 cm, h. 11.8-12.5 cm; back l. 50.3 cm; m. 54 / 54.2 kg
Secondary Markings/Features:
a) ỊṂP̣·CAEṢ (stamped on front face)
b) XLVII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 47 *librae* over 120, although conversion of current weights comes to 45 or 46 *librae*. Trace of another stamp are visible on the left end.

60.83 Lead ingot L&D2 2.75; MAA inv. SM1.83.4311
Type: D1.2
Metrics: l. 53.2 cm, w. 9.7-10.2 cm, h. 10.7-11.9 cm; back l. 50.5 cm; m. 48.5 / 48.8 kg
Secondary Markings/Features:
a) [..]Ṃ[…]ẸS (relief stamped on front face)
b) L·FL·VE (VE in ligature; stamped on right end)
c) XXIIX (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 28 *librae* over 120, which is consisten with current weight.

60.84 Lead ingot L&D2 2.76; MAA inv. SM1.84.4312
Type: D1.2
Metrics: l. 53.5 cm, w. 10.7 cm, h. 11.9-12.6 cm; back l. 51.6 cm; m. 58.2 / 58.8 kg
Secondary Markings/Features:
a) [.]ṂP·CAES (stamped on front face)
b) […]L·VE (VE in ligature; stamped on left end)
c) LIX (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b), and (b) as in 60.9(a). Inscription

(c) indicates a weight of 59 *librae* over 120, which is consistent with current weight.

60.85 Lead ingot L&D2 2.77; MAA inv. SM1.85.4313

Type: D1.2
Metrics: l. 54.2 cm, w. 10.1 cm, h. 11.8 cm; back l. 49.5 cm; m. 53.5 / 54.4 kg
Secondary Markings/Features:
a) [….]Ç[…] (relief stamped on front face)
b) [.]ṾẸ[.] (stamped on right end)
c) XLVII (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b) and (b) as in 60.9(a). Inscription (c) indicates a weight of 47 *librae* over 120, although conversion of current weights comes to between 44 and 46 *librae*.

60.86 Lead ingot L&D2 2.78; MAA inv. SM1.86.4314

Type: D1.2
Metrics: l. 53.2 cm, w. 10 cm, h. 12.1-12.8 cm; back l. 51.5; m. 53 kg
Secondary Markings/Features:
a) [….]C[..]S (stamped on front face)
b) […]L·Ṿ[.] (stamped on right end)
c) XL (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b), and (b) as in 60.9(a). Inscription (c) indicates a weight of 40 *librae* over 120, although conversion of current weight comes to 42 *librae*.

60.87 Lead ingot L&D2 2.79; MAA inv. SM1.87.4315

Type: D1.2
Metrics: l. 53.7 cm, w. 9.7-10.3 cm, h. 11.6-12.2 cm; back l. 49.8; m. 53.3 / 52.8 kg
Secondary Markings/Features:
a) ỊṂP̣·Ç̣ẠẸṢ (stamped on back)
b) XLII (stamped on left end)
Notes: Inscription (a) interpreted as in 60.1(b). Inscription (b) indicates a weight of 42 *librae* over 120, which is consistent with current weight.

60.88 Lead ingot L&D2 2.80; MAA inv. SM1.88.4316

Type: D1.2
Metrics: l. 52.8 cm, w. 10.6 cm, h. 11.3-12.6 cm; back l.49.7; m. 52.9 / 52.6 kg
Secondary Markings/Features:
a) [..]P CA[..] (stamped on back)
b) L·FL·VE (VE in ligature; stamped on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). No weight inscription was found.

60.89 Lead ingot L&D2 2.81; MAA inv. SM1.89.4317

Type: D1.2
Metrics: l. 53.4 cm, w. 10.3 cm, h. 12 cm; back l. 50 cm; m. 56.9 / 56.8 kg
Secondary Markings/Features:
a) [….]CAES (relief stamped twice on front face)
Notes: Inscription (a) interpreted as in 60.1(b). The right side is well preserved and no inscriptions are present; the left side is too concreted to discern any markings.

60.90 Lead ingot L&D2 2.82; MAA inv. SM1.90.4318

Type: D1.2
Metrics: l. 53.5 cm, w. 10.5 cm, h. 11.5 cm; back l. 51 cm; m. 57.5 / 57.8 kg
Secondary Markings/Features:
a) ỊṂP̣·Ç̣ẠẸṢ (stamped twice on front face, one incomplete)
b) L·F[….] (stamped on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Traces of a possible freehand inscription appear on the left

60.91 Lead ingot L&D2 2.83; MAA inv. SM1.91.4319

Type: D1.2
Metrics: l. 53.5 cm, w. 10.3 cm, h. 10.4-11.3 cm; back l. 51; m. 46.6 kg
Secondary Markings/Features:
a) [.]MP Ç̣ẠẸṢ (stamped on back)
b) [..]FḶ·VE (VE in ligature; stamped twice on right end)
c) XXI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 21 *librae* over 120, although conversion of current weight comes to 22 or 23 *librae*.

60.92 Lead ingot L&D2 2.84;

MAA inv. SM1.92.4320
Type: D1.2
Metrics: l. 52.9 cm, w. 10.4 cm, h. 12-12.6 cm; back l. 50 cm; m. 55.9 / 56.2 kg
Secondary Markings/Features:
a) [….]Ç[…] (relief stamped on front face)
b) […]Ḷ·VE (VE in ligature; stamped on left end)
c) LI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 51 *librae* over 120, which is consistent with current weight.

60.93 Lead ingot L&D2 2.85; MAA inv. SM1.93.4321
Type: D1.2
Metrics: l. 53 cm, w. 10.3 cm, h. 11.4 cm; back l. 49.4 cm; m. 53.3 / 53.6 kg
Secondary Markings/Features:
a) [.]MP·CAES (stamped on front face)
b) Ḷ·F̣Ḷ[…] (stamped on right end)
c) XLV (freehand on left end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 45 *librae* over 120, although conversion of current weight come to 43 or 44 *librae*.

60.94 Lead ingot L&D2 2.86; MAA inv. SM1.94.4322
Type: D1.2
Metrics: l. 52.8 cm, w. 9.8-10.3 cm, h. 11.2-11.9 cm; back l. 49.7 cm; m. 52.1 / 51.8 kg
Secondary Markings/Features:
a) IVN (freehand on back)
b) IMP·C[…] (stamped on front face)
Notes: Inscription (a) appears to be part of a name (Iunius?), but appears on no other ingot in this batch. Inscription (b) interpreted as in 60.1(b). The left side is well preserved and no inscriptions are present; the right side is too concreted to discern any markings.

60.95 Lead ingot L&D2 2.87; MAA inv. SM1.95.4323
Type: D1.2
Metrics: l. 53.3 cm, w. 9.9 cm, h. 11.9 cm; back l. 49 cm; m. 53.8 / 53.6 kg
Secondary Markings/Features:
a) IMP·CAE[.] (stamped five times on front face; three with only the first three letters)
b) EROTI[.] (stamped twice on rear face)
c) [..]F̣Ḷ·VE (VE in ligature; stamped twice on left end, once on right end)
d) XLII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); (b) as in 60.10(c); and (c) as in 60.9(a). Inscription (d) indicates a weight of 42 *librae* over 120, although conversion of current weights comes to 44 or 45 *librae*.

60.96 Lead ingot L&D2 2.88; MAA inv. SM1.96.4324
Type: D1.2
Metrics: l. 53.2 cm, w. 9.8-10.4 cm, h. 11.3-11.7 cm; back l. 50.3 cm; m. 53.1 / 53.2 kg
Secondary Markings/Features:
a) IMP·C[…] (relief stamped twice on front face)
b) L·F̣Ḷ·VE (stamped on left end)
c) XLII (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 42 *librae* over 120, which is consistent with current weight.

60.97 Lead ingot L&D2 2.89; MAA inv. SM1.97.4325
Type: D1.2
Metrics: l. 53.4 cm, w. 10.7 cm, h. 10.5-12.4 cm; back l. 50.8 cm; m. 54.8 / 54.6 kg
Secondary Markings/Features:
a) [..]P·CAES (relief stamped on front face)
b) Ḷ·FL·VE (stamped on left end)[769]
c) XLI (freehand on right end)
Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 41 *librae* over

[769] The original publication does not indicate that the VE were in ligature, but as this is not consistent with all the other instances of this stamp, it is most likely a typographical error.

120, which is consistent with current weight.

60.98 Lead ingot L&D2 2.90; MAA inv. SM1.98.4326

Type: D1.2

Metrics: l. 54.5 cm, w. 10.5 cm, h. 12.2 cm; back l. 51 cm; m. 59 / 58.8 kg

Secondary Markings/Features:

a) ỊṂP·ÇẠẸṢ (stamped on front face)

b) […]L·VERV (VE and RV in ligature; stamped on left end)

c) LXI (freehand on left end)

Notes: Inscription (a) interpreted as in 60.1(b); and (b) as in 60.9(a). Inscription (c) indicates a weight of 61 *librae* over 120, although conversion of current weight comes to 60 *librae*.

60.99 Lead ingot L&D2 2.91; MAA inv. SM1.99.4327

Type: D1.2

Metrics: l. 50 cm, w. 9.1-9.5 cm, h. 12 cm; back l. 4 cm; m. 47 kg

Secondary Markings/Features:

a) [..]MP·CAES (relief stamped on front face)

b) L·FL·VE (VE in ligature; stamped on right end)

c) XXIIII (freehand on right end)

Notes: Inscription (a) interpreted as in 60.1(b); and (c) as in 60.9(a). Inscription (c) indicates a weight of 24 *librae* over 120, which is consistent with current weight.

61) Porto Pistis

Region: Western Sardinia BA 48:A3

Date: 117-138 C.E.

Cultural Affiliation: Roman

Number of Lead Ingots Found: 8 preserved; approx. 40 reported

Discussion: A group of at least 40 ingots was recovered off the town of Pistis, Sardinia, in 1987, with no associated cargo or hull remains. Many of the ingots were lost to looters, but 8 were preserved. The ingots were all stamped with the name of the emperor Hadrian and were freehand with a series of numbers that Zucca believes may indicate a sequence or count rather than weights, with the 'C' interpreted as *censitum* (counted).[770] Thus the suriving ingots of the series would be 11, 23, 24, 25, 26, 28, 29, 30. A sample from one ingot was traced to the Iglesiente mining district of southwestern Sardinia using lead isotope analysis.[771] This is important evidence for the shift of lead production in the eastern Mediterranean in the wake of declining Iberian output.

References: Agus 1990; Parker 1992a, 338; Zucca 1991; Pinarelli 1995, 85.

61.1) Lead ingot Zucca 1991: 2

Type: D4.1

Metrics: l. 39.5 cm, w. 12 cm, h. 11 cm; back l. 35.5 cm, w. 7.9 cm; m. 35.6 kg

Mold mark(s):

a) IMPCAESHADRAVG (cartouche: l. 32.1, w. 4.8 cm; mlh: 4 cm)

Secondary Markings/Features:

b) C XXV (freehand on rear face; h. of 'C': 2.5 cm, of others 0.9 cm)

Notes: Described by Zucca as truncated pyramid. Inscription (a) interpreted as *Imp(eratoris) Caes(aris) Hadr(iani) Aug(usti)*; see above for discussion of (b), 'C' is squared off. Located at Museo Archeologico di Cagliari

61.2) Lead ingot Zucca 1991: 3

Type: D4.1

Metrics: l. 37 cm, w. 11 cm, h. 9.5 cm; back l. 34 cm, w. 6.5 cm; m. 33.5 kg

Mold mark(s):

a) IMPCAESHADRAVG (cartouche: l. 32.1, w. 5.1 cm; mlh: 3.4 - 3.5 cm)

Secondary Markings/Features:

b) C XI (freehand on front face; h. of 'C': 1.3 cm, of others 0.8 cm)

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[770] The possibility that the letter stands for 'CAES' as attested in the Caesarea ingots (59.1-4) cannot be ignored.

[771] This region, rich in argentiferous lead ores, was exploited for silver under the Carthaginians, and likely earlier, but was apparently relatively inactive during the late Republic and early Empire in favor of the rich supplies in Spain (Davies 1935, 69-70).

Notes: For inscription (a), see 61.1(a). Located at Antiquarium Arborense, Oristano.

61.3) Lead ingot Zucca 1991: 4
Type: D4.1
Metrics: 1. 37.5 cm, w. 13.5 - 14 cm, h. 9.8 cm; back l. 33.5 cm, w. 6.2 cm; m. 38.5 kg
Mold mark(s):
a) IMPCAESHADRAVG (cartouche: l. 31.4, w. 5.5 cm; mlh. 3.8 cm)
Secondary Markings/Features:
b) C XXIII (freehand on front face; h. of 'C': 1.7 cm, of others: 1.2 cm)
Notes: For inscription (a), see 61.1(a). Same location as 61.3.

61.4) Lead ingot Zucca 1991: 5
Type: D4.1
Metrics: 1. 39.5 cm, w. 13 cm, h. 8.5 - 10 cm; back l. 34.5 cm, w. 6.5; m. 39.5 kg
Mold mark(s):
a) IMPCAESHADRAVG (cartouche: l. 31.9, w. 5.1 cm; mlh. 3.5 cm)
Secondary Markings/Features:
b) C XXIX (freehand on front face; h. of 'C': 1.3 cm, of others: 1.1 cm)
Notes: For inscription (a), see 61.1(a). Same location as 61.3.

61.5) Lead ingot Zucca 1991: 6
Type: D4.1
Metrics: 1. 38.5 cm, w. 12.5 cm, h. 10 cm; back l. 34.5, w. 6.2 cm; m. 37.4 kg
Mold mark(s):
a) IMPCAESHADRAVG (mlh. 3.4 - 3.6 cm)
Secondary Markings/Features:
b) C XXX (freehand on rear face; h. of 'C': 1.5 cm, of others: 1.2 cm)
Notes: For inscription (a), see 61.1(a). Same location as 61.3.

61.6) Lead ingot Zucca 1991: 7
Type: D4.1
Metrics: l. 37.6 cm, w. 13 cm, h. 8.8 - 9.7 cm; back l. 34 cm, w. 6.9(?) cm; m. 36.5 kg
Mold mark(s):
a) IMPCAESHADRAVG (cartouche measurements not given; mlh. 3.5- 3.7 cm)
Secondary Markings/Features:
b) C XXIV (freehand on rear face; h. of 'C': 1.7 cm, of others: 0.9 cm)
Notes: For inscription (a), see 61.1(a). Located at Guspini, Deposito Archeologico Comunale. Numeral in (b) based on drawing in Zucci rather than text, where XXIX was printed; the dimension of 6.9 cm was given as the border around the cartouche, but that does not match the drawing, and is believed to be width of back.

61.7) Lead ingot Zucca 1991: 8
Type: D4.1
Metrics: l. 39.5 cm, w. 11.9 cm, h. 9.6 - 9.9 cm; back l. 35.2 cm, w. 7 cm; m. 38.1 kg
Mold mark(s):
a) IMPCAESHADRAVG (cartouche: l. 32.3, w. 4.9 cm; mlh. 3.8 - 3. 9 cm)
Secondary Markings/Features:
b) C XXVI (freehand on front face; h. of 'C': 1.8 cm, of others: 1.0 cm)
Notes: For inscription (a), see 61.1(a). Located at Guspini, Deposito Archeologico Comunale.

61.8) Lead ingot Zucca 1991: 9
Type: D4.1
Metrics: l. 37.6 cm, w. 13 cm, h. 9.4 - 10.4 cm; back l. 34.7, w. 7.6 cm, m. 39.4 kg
Mold mark(s):
a) IMPCAESHADRAVG (cartouche: l. 32.5, w. 5.0 cm; mlh. 3.8 - 4.0 cm)
Secondary Markings/Features:
b) C XXVIII (freehand on rear face; h. of 'C': 2.5 cm, of others: 1.8 cm)
Notes: For inscription (a), see 61.1(a). Same location as 61.7.

62) Saint Gervais A
Alternate names: Saint Gervais 1
Region: Bouches-du-Rhône *BA* 15:D3
Date: ca. 140 C.E.
Cultural Affiliation: Roman
Number of Lead Ingots Found: 4
Discussion: The ship's primary cargo was iron bars (averaging 3.1 x .55 x .028 m) with a total estimated weight of 6,035 kg. The wreck, first discovered in 1966, is dated based on the reigns of the two emperors represented in the ingot inscriptions. The possible parallels with British ingots (cf.

58), combined with the wreck's location, just east of the mouth of the Rhone, suggests this metal cargo may have been coming down from the north rather than up from Spain. Lead isotope analysis data, however, has not been published for these ingots. Due to its easily accessible location and the state of the cargo recovered, it is believed this wreck was salvaged at various points in the past, possibly even in antiquity. Another ingot has been reported from this area, but does not appear to be connected with this site.[772]
References: Monguilan 1987; Pollino 1984, Fig 8; Parker 1992a, 372.

62.1) 4 Lead ingots
Type: D4.2
Metrics: l. 61 cm, w. 15 cm, h. 12 cm; back l. 51 cm, w. 9 cm; m. ca. 90 kg
Mold mark(s):
a) IMP HADRIANI AVG (on one ingot)
b) IMP·CAES·ANTONINI AVG·PII (on three ingots)
Secondary Markings/Features:
c) *raised outline of a circle* (on right end of one of the Antonine ingots)
d) cubic indentation in base of some of the ingots (dimensions not given)
Notes: Inscriptions are interpreted as (a) *Imp(eratoris) Hadriani Aug(usti)* and (b) *Imp(eratoris) Caes(aris) Antonini Aug(usti) Pii*. Mark (c) is visible in a figure in Monguilan, but it is not addressed in the text;[773] it is possible there was a symbol or image inside the circle. Chemical analysis showed the ingots to be over 99% pure, with impurities totaling approximately 0.1%. Monguilan believes the square holes are related to casting (cf. **57**), rather than nail holes for transport (cf. **36**, **41**, **45**, **48**). The weight of these ingots is unusual in the Mediterranean, with the closest parallels coming from terrestrial finds in Britain.[774]

63) Ploumanac'h
Alternate Names: Malban
Region: Côtes-d'Armor *BA* 7:C3
Date: 3rd-4th c. AD?
Cultural Affiliation: Celtic?
Number of Lead Ingots Found: 271 (analysis based on 197)
Discussion: This collection of ingots was found in 1983 in a rocky area with very strong currents, which may help explain why very few associated artifacts survived. L'Hour, however, suspects that the site represents a partial cargo jettisoned to lighten the ship's load. This is unlikely considering the close grouping of the ingots on the sea floor. An estimated total of 22 tons of lead was recovered, and the ship is believed to have been 20-30 m in length. Additional cargo may have consisted of ceramic tiles, fragments of which were found at the site, along with portions of two millstones.

Inscriptions link the ingots to Celtic tribes of Britain. There was little consistency in shape and weight, showing an overall lack of standardization, consistent with non-centralized production. The three basic shapes found are described as genarally quadrangular bars (190 ingots), classified here as B1.13; "flat and circular" (75 ingots; often found under the bars), classified as A1; "bell-shaped or half-moon" (6 ingots), classified as B2.3. The ingots were cast in sand rather than ceramic or stone molds. Weights range from 27 to 150 kg. No pattern connects weight, inscriptions and shape.

Three types of inscriptions have been identified, most of which are secondary

[772] Long and Domergue (1995, 820) note it is in possession of the Musée Archéologique d'Istres (inv. no. 714) and bears the mold mark SOCIORVM *ivy* PLVMB *ivy* GERM.
[773] Monguilan 1987, 174 (no figure number).

[774] Among the many British ingots in this weight range in *RIB*, three ingots stamped IMP HADRIANI AVG are reported from Shropshire and Montgomeryshire in 2404.28 – 2404.30 with the following weights: 86.3 kg, 86.64 kg, 86.2 kg; from the same region is an ingot of 86.27 kg stamped IMP VESP·AVG·V·T·IMPIII[*CON*]S (2404.31).

marks, although some names in relief are mold marks. Most of the ingots bear freehand numerals, presumed to indicate weight, possibly comprising two separate weight standards (260-280 g for ingots below 60 kg, and 300-320 g for ingots 60-140 kg). Some ingots bear name inscriptions and some have symbols or monograms, either freehand or possibly stamped from a die. The letters are often relevatively crude and uneven.

Chemical analysis of the ingots showed lead content ranging from 99.89-99.98%; additional elements included a significant amount of Cu, 0.02-0.05% Ag, trace amounts of Fe and Sb, and an absence of Bi. Lead isotope analysis, covering three different ingot inscription groups, showed all ingots originated from the same ore body, though no connection to a specific mining x

References: L'Hour 1986; L'Hour 1987a; L'Hour 1987b; Parker 1992a, 320.

63.1) 271 lead ingots

Type: A1, A3, B2.3

Metrics: dimensions not given; Type A1: m. 27 – 140 kg; Type B1.1: 29-150 kg; Type B2.3: 38-141 kg.

Primary and/or Secondary Stamp(s):

a) A group of 14 inscriptions incorporate the abbreviation BR, interpreted as representing the tribe Brigantes.[775] These include CIVT BR GZINILI ZAL (ingot 172), CIVTBR (ingot 398), and CBRIGAN (ingot 401). The BR is usally in ligature. The beginning of the former is interpreted as *Civ(i)t(as) Br(i)g(antum).* As the Brigantes did not officially become a *civitas* until the reign of Hadrian, the terminus post quem of the wreck is considered to be ca. 115-138 C.E. There are many known lead deposits in Derbyshire that fell within in the tribe's territory.

b) A group of 5 inscriptions are believed to refer to the tribe Iceni, best represented by CIVT ICIINP CCC (Ingot 298) and CIVTICCENORP (ingot 28). The former is interpreted as *Civ(i)t(as) Iciin(orum) p(ondo) 300.* The Iceni are not linked to lead mining, and their territory, roughly equivalent to modern day Norlfolk on the central east coast of England, had little lead. They can be linked, however, to pewter production, leading to the suggestion that this inscription represents the purchaser rather than the producer. This is a tentative explanation at best and is not consistent with the location of the wreck in French waters.

c) A group of inscriptions represent personal names, including: CIVT BRỌ SINILI[S] (with initial S reversed, ingot 75), SEGETI (ingot 282), TẠCLEMENTINI (ingot 141), CVNOVEN (ingot 14), CB C CIVILIS AL (ingot 31), LATINI (ingot 58), and (tentatively) TVSCANI (ingot 288). Both Sinilis and Civilis have been attested in the fourth century C.E.,[776] suggesting a late Imperial date for the wreck.

d) MIVS (in a small cartouche, l. 7.5 cm, w. 2.5 cm) was stamped on approximately 80 ingots. The letters are not clear in all cases, in which case they are presumed, based on the presence of the cartouche.

Notes: Based on published material I am unable to determine how many stamps are primary, although at least one inscription is in relief and must therefore be primary; [777] most, however, are secondary. The numeric figures appear to be freehand, but some of the names may have been stamped from dies.

64) Le Petit Rhone

Region: Bouches-du-Rhône *BA* 15:C3

[775] Parker (1992a, 320), however, notes that not everyone is convinced of this interpretation, suggesting they represent personal names, and also that certain instances with BR in proximity to a C might indicate *C(lassis) Br(itannica).*

[776] Ammianus Marcellinus (27.8.10) notes that in 368 C.E. Valentinian appointed a man named Civilis *praefectus* of Britain; a temple dedication in Lydney mentions a T. Flavius Senilis, *praefectus reliquationes*¸ some time after 367 C.E. (L'Hour 1987a, 143).

[777] See L'Hour 1987b, Fig. 22.

Date: 3rd-4th c. C.E.?
Cultural Affiliation: Roman
Number of Lead Ingots Found: 6
Discussion: One ingot was reported in 1985, found in isolation near the mouth of the Petit-Rhône, with no associated hull or cargo. As its shape and general location were the same as five ingots found together by a fisherman in 1982, all are presumed to have come from the same depositional event. Inscribed Roman letters link them to Roman production, and their similarity in shape to some ingots from the Ploumanac'h wreck (**63**) suggests a contemporaneous date.
References: Marechal 1985; Parker 1992a, 309.

64.1) Lead ingot
Type: B2.3
Metrics: d. 35-38 cm, h. approx 13 cm; m. approx. 70 kg.
Secondary Markings/Features:
a) CCXX (freehand on back)
Notes: The ingots were described as being semi-spherical like those on Ploumanac'h (**63**).

65) Dor
Region: Haifa *BA* 69:A4
Date: 1st -3rd c. C.E.?
Cultural Affiliation: Roman
Number of Lead Ingots Found: 4
Discussion: This group of four ingots was found together with two lead sounding weights by fishermen in 1988. The site reportedly also held remains of pottery vessels, a collection of lead and bronze objects and a lead anchor stock. The location of the wreck was not disclosed to archaeologists, who purchased the ingots from the fisherman for their scrap value.

Kingsley and Raveh suggest a date of the first century B.C.E. based on a lead anchor stock, left at the site, but described by the fisherman; such stocks on the Israeli coast generally date to the second or first century B.C.E. They do point out, however, that such stocks have been found as late as ca. 300 C.E. in other areas of the Mediterranean. Raban believes the ingots date from the late Empire due to the presence of Greek letters in two of the stamps and the overall non-uniformity of the ingots, which suggests a decline in standardized production.

The ingots are roughly trunco-pyramidal but without cartouches, with rough surfaces and an overall asymmetrical longitudinal profile. The ingots are noticeably lighter than the 33 kg standard expected of early first century C.E. ingots. There is some similarity to a number of Comacchio ingots (**39.43-102**), which must be noted as a precedent for the occurrence of crude casting and highly variable weights in a period of otherwise highly standardized lead output. Due to the lack of cartouche, these ingots have not been assigned a Domergue classification, but rather a basic mold-made type as with the Comacchio ingots.
References: Kingsley and Raveh 1994 (K&R); Raban 1999, 185.

62.1) 1 Lead ingots K&R ingot A
Type: B1.2
Metrics: l. 44.7 cm, w. 11.3 cm, h. 8.2 cm; m. 29.4 kg
Secondary Markings/Features:
a) ΓBB (relief stamped on base; l. 3.1 cm, w. 2 cm)
b) ΓBK (relief stamped on base; l. 3.1 cm, w. 1.8 cm)
Notes: A rounded, elongated protrusion runs along the back.

62.2) 1 Lead ingots K&R ingot B
Type: B1.2
Metrics: l. 43.8 cm, w. 11.2 cm, h. 6.0 cm; m. 25.05 kg
Secondary Markings/Features:
a) . BK (relief stamped on base; l. 2.3 cm, w. 2 cm)
b) ΓBB (relief stamped on base; l. 3.1 cm, w. 2 cm)
Notes: Stamp (a) is likely an incomplete version of 65.1(a).

62.3) 1 Lead ingots K&R ingot C
Type: B1.2
Metrics: l. 38.9 cm, w. 8.4 cm, h 8.9 cm; m. ca. 18.5 kg
Secondary Markings/Features:
a) COL (relief stamped on base; l. 3.3 cm, w. 1.6 cm)

b) CO (relief stamped on base; l. 2.3 cm, w. 1.6 cm)
Notes: Ingot is noticeably shorter in length and width than the other ingots in the group. Weight is described as "provisional."

62.4) 1 Lead ingots K&R ingot D
Type: B1.2
Metrics: l. 42.5 cm, w. 11.3 cm, h. 5.8 cm; m. 23.25 kg
Secondary Markings/Features: none
Notes: Slight protrusion on one side of the ingot.

Unknown

66) Les Magnons B
Region: Var *BA* 15:F3
Date: unknown
Cultural Affiliation: Greek?
Number of Lead Ingots Found: 19
Discussion: Discovered in 1963, these ingots were opencast in rough plano-convex discoid (A1) and elongated shapes (A4), and varied in weight from 7 to 28 kg, for a total of approximately 250 kg of lead. These ingots were found in association with bars of brass (79% copper, 21% zinc) 20-50 cm in length. Ancient production of large quantities of brass was limited primarily to the Romans, based on the introduction of brass coinage in 46 B.C., although it was known to some extent before then.[778] There is also a possibility that the brass and lead were deposited at separate times.

No other associated artifacts were found, making dating very uncertain. The lead ingots bear various punched symbols and letters, some of which appear to be Greek. Pollino notes similarities with marks on ingots from the Ploumanac'h wreck (**63**) and believes the Magnons ingots are connected to pre-Roman Celtic activity, despite the late Imperial date of the Ploumanac'h wreck. Due to their proximity to Marseilles, they may have been derived from Greek colonial commerce with inland Celtic producers, but the possibility that these ingots reflect the late Roman period production cannot be ruled out.[779]
References: Dumas 1972, 181-5; Pollino 1984, 11-12; Parker 1992a, 251-2.

67) Punta della Contessa
Region: Apulia *BA* 45:H3
Date: unknown
Cultural Affiliation: Roman?
Number of Lead Ingots Found: 3 recovered of a reported "cargo"
Discussion: This site was reported only in brief as a cargo of ingots. No associated artifacts or hull remains were mentioned. Three lead ingots were recovered and installed at the Museo Provinciale di Brindisi (inv. 14165, 14166, 14167). Based on photographs, they appear to be of truncated pyramid form with a relatively wide back, resembling most closely type D4. There is, however, no cartouche on the back; the ingots instead bear a top-down view of a crustacean in relief where a cartouche would normally be. One ingot was reportedly 34.5 cm in length. They are presumed to be Roman, but have no additional markings to support this. Ingots from Baie de l'Amitié (**54**) and Rena Maiore (**46**) also had images in relief rather than letters, suggesting a possible Imperial date.

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[778] Tylecote 1992, 69-70. The earliest brass artifacts cited by Forbes (1950, 278) are from Gezer and date to 1400-1000 B.C.E., with a zinc content as high as 23.4%, but pre-Roman finds with such high zinc content are very rare.

[779] A collection of 10 brass and 2 lead ingots were acquired by the Bochum museum in 1980, reportedly recovered from an underwater site near Corsica (Weisberger 2007). The lead ingots appear to be D4 with no inscription in the cartouche, and unusual textile impressions on the surface, suggesting less standardized, later Roman production. A Dressel 7/11 amphora fragment was found nearby, suggesting a first century C.E. date. The brass ingots are type A2, unlike those reported from Les Magnons, but have a comparable zinc content (ca. 24-26%), suggesting possible contemporaneity.

References: Sciarra 1982, 129; Sciarra 1985, 145 and Plate II;[780] Parker 1992a, 351.

68) Agde H

Region: Hérault *BA* 15:B3
Date: unknown
Cultural Affiliation: unknown
Number of Lead Ingots Found: galena only
Discussion: This cargo of galena was reported only in brief in 1964. There were no datable materials found in association with the site, but it is believed to be of ancient date.
References: Parker 1992a, 45.

[780] Sciarra (1985) reports the location as Punta Cavallo but the caption in Plate II is labeled Punta della Contessa. The Capo di Torre Cavallo is located adjacent to Punta della Contessa and thus the names likely refer to the same site.

APPENDIX B

THE *GERM* PROBLEM

One difficulty in the interpretation of inscriptions on lead ingots of the Roman Imperial period has to be noted. The use of the abbreviation GER or GERM has caused much confusion and the matter has still not been entirely settled. This string has appeared in inscriptions of imperial names, *socii*, and private citizens, in both mold marks and secondary stamps (tab. B.1). The traditional interpretation has been as a cognomen or title, *Germanici*, in the genitive, modifying IMP CAES. This is relatively straightforward for certain imperial names, such as Domitian, who is known to have assumed the title of Germanicus in 83 C.E.[781] Other inscriptions, however, only include the titles of Caesar and Augustus, suggesting the emperor Augustus was intended, who never adopted this title.

Table B.1. Known lead ingots with an inscription containing the string 'GER.'

Variant	**Inscription**	**Type**	**Wreck**	**Ingot(s)**
GER	IMP DOMIT AVG GER	Mold mark	Runcorn	58.2
	IMP DOMIT CAESARIS AVG GER	Mold mark	Caesarea	59.1-4
GERM	P TVRPIL GERM	Secondary stamp	Sud Perduto B	45.2-25
	CAESAR AVG IMP GERM TFCF	Mold mark	Ile Rousse	50.1
	FLAVI VERVCLAE PLVMB GERM	Mold mark	Sainte-Maries-de-la-Mer 1	60.1-8
	SOCIORVM PLVMB GERM	Mold mark	Anse St. Gervais	*Benoit*[782]
GERMANICVM	AVGVSTI CAESARIS GERMANICVM	Mold mark	Rena Maiore	46.1

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[781] The title Germanicus was associated, either by birth or through military action, with emperors Caligula, Claudius, Vitellius, Domitian, Nerva, Trajan, Marcus Aurelius, and Commodus.
[782] Benoit 1958, 36.

Further confusion was introduced by the ingots from Rena Maiore (**46**), which bore an unusual inscription with no abbreviation, reading AVGVSTI CAESARIS GERMANICVM. In this case the term *Germanicum* is not in the genitive, and thus does not agree with the other imperial titles that are in the genitive, but rather with *plumbum*, the unstated object of the genitive phrase, implying a German origin for the lead. The phrase "PLVMB GERM" found on eight ingots from Saintes-Maries-de-la-Mer 1 (**60**), clearly suggests the word is intended to describe the lead. As the ingots themselves resemble those from Spain, and few ingots were known from land sites in Germany when the wreck was first published, scholars initially suggested the that adjective *germanus* was intended, meaning "genuine" or "true."[783] Lead isotope analysis of the Saintes-Maries-de-la-Mer metal, however, supports a German origin for those ingots, generally dispelling the proposed qualitative meaning.[784]

The region of Germany identified in the isotopic analysis raises further questions. The metal was consistent with ores from an area of the Sauerland, east of the Rhine, which was only under Roman control between 7 B.C.E. and 9 C.E.[785] Assuming the Saintes-Maries ingots were produced at a mine in this region during that period, this would make them the oldest type D4 ingots yet found and place the shift in ingot style and weight standard at the beginning of the empire. Whether such a date is consistent with the other artifacts found at this site is unclear based on published materials, since the main focus of most articles is the ingot cargo. One must be careful to take all factors into consideration before entirely rearranging the chronology of ingot development established over the last several decades of scholarship; however, this dating has been tentatively accepted here.

Finally, the ingots from the Sud Perduto B wreck (**45**), comfortably identified as a product of the Sierra Morena district of Spain, show the use of GERM as personal name in the secondary stamps of *P. TVRPIL GERM.* Thus, the string GER/GERM

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783 Long and Domergue 1995, 821.
784 Rothenhöfer 2003, 280; Eck 2004, 20-1.
785 Eck 2004, 21.

appears to have been used in various circumstances to indicate an imperial title, a private *cognomen*, and a region of origin.[786] Extra care must be taken, therefore, in interpreting ingots bearing any form of this string.

[786] The string “TFCF” which follows the GERM on the ingot from Ile Rousse (**50.1**) has yet to be accurately interpreted, making it difficult to decide whether the GERM is a titular or geographic designation.

VITA

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