

# On the Origin of Specie

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## Abstract

*Highly preliminary and incomplete.*

The first coinage arose in 7th c. Asia Minor. It presented a full range of denominations, produced with great precision of weight. But the content was highly variable: it was a natural mixture of gold and silver, which seems to have been diluted with silver. Why use what is in essence a lottery ticket to create the first circulating coinage? Existing explanations are found wanting. Data from late modern coin circulation indicates that the early electrum coins did circulate.

# 1 Introduction

Coinage, which constitutes the canonical form of money, has been a part of human history for over 2600 years. It consists of metallic objects produced to a specific standard of weight, with a range of denominations, for use in transactions. It is also usually produced to a specific standard of fineness, so that the intrinsic content in metal is well-defined (although variations in the standard over time represents an interesting part of monetary history). Traditional, as well as modern, theories of money emphasize the importance of recognizability as a key feature of monetary objects.

Yet the birth of coinage presents an interesting puzzle. The first coins, produced in Asia Minor in the 7th century BC, were made of a material that was neither gold nor silver, but a mixture of the two, called electrum. Moreover, the mixture appears to have varied widely of the (relatively) short duration of this type of coinage, ultimately replaced with pure gold and pure silver coins. Yet the coins were made to a precise standard of weight. The purpose of this paper is to gather the facts about this first coinage and review the existing theories. The problem of early electrum coinage presents, in my view, an interesting challenge to monetary economics.

## 2 Historical evidence

### 2.1 *The context*

The origin of coined money is in Asia Minor, or Western Turkey. The middle coast of Turkey on the Aegean Sea had been settled by Greek-speaking peoples in the 11th or 10th century BC. The regions inland were occupied by various Anatolian populations, speaking languages related to Hittite; among the latter were the Lydians, centered on the city of Sardis. It is in this area, at the boundary between the Greek and the Anatolian worlds, that money was first coined (Figure 1).

The Lydians (Roosevelt 2009) had been living in the area of Sardis since at least the 12th century BC, but rose to prominence under the Mermnad dynasty founded by King Gyges (680–644 BC). Gyges (called “rich in gold” by the contemporary poet Archilochos) and his successors down to Alyattes (610–560 BC) and Croesus (560–546 BC) worked to extend their domination over Western Anatolia and frequently fought with the Greek cities of Ionia, taking them but never completely establishing full control. Even under Croesus, the last Mermnad king, episodic warfare (or raiding) took place along the coast (Pedley 1972, 18–27).

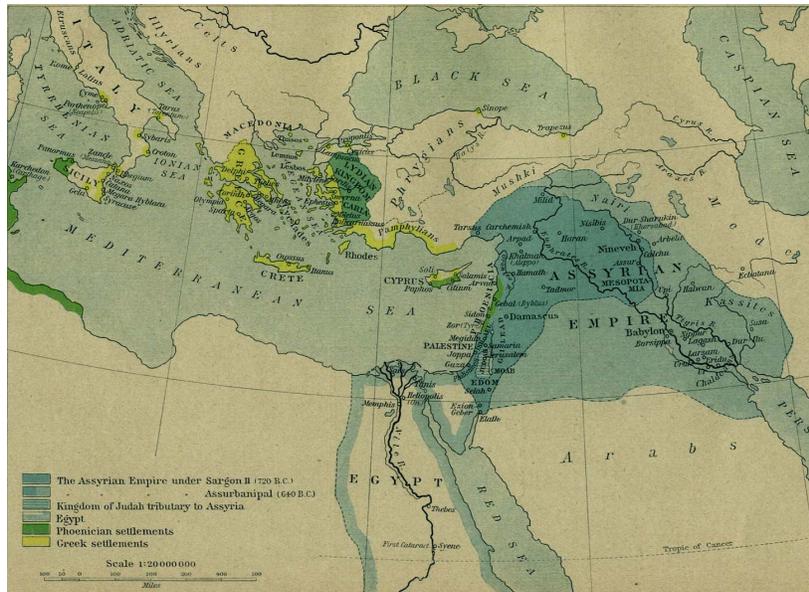


Figure 1: The Assyrian Empire and the Eastern Mediterranean, 750–625 BC.

Lydia was renowned in ancient times for its rich valleys and plentiful upland grazing grounds. The archaeological record attests to agriculture (wheat and barley) and tree-crop cultivation (olives, nuts, figs). The region was known for its wines whose exports may be related to the spread of the cult of the Lydian god Baki or Bacchos (Hanfmann 1983, 5). Sheep and cattle were raised, as well as fine-wool producing goats and renowned horses. Lydian crafts were also reputed: the Greeks placed in Lydia the legend of Arachne. This boastful weaver provoked the goddess Athena’s ire when she compared their skills and was changed into a spider (Roosevelt 2009, 49–54, 70–77). Sardis at the time of its peak is believed to have numbered 20,000 inhabitants or more (Hanfmann 1983, ?).

## 2.2 Before coins

Evidence from burials shows that gold has been valued and used as jewelry since the 5th millenium BC, and silver since the 4th millenium BC. Written records from Mesopotamia show that silver was commonly used as unit of account for centuries, almost exclusively after 1500BC. Curiously, prices are always expressed in purchasing power of a unit of silver, that is, “1 shekel is equivalent to X units of . . .” Archaeological evidence documents a growing number of hoards in the Middle East, especially in

Phoenicia and Syria, from the 10th to the 7th centuries, containing was is called *Hacksilber*, namely, pieces of silver that are cut up from ingots in apparently random quantities (Thompson 2003). However, nothing that could properly be called coinage is documented in the Middle East before the emergence of coinage in Lydia in the 7th c. BC. Even Egypt did not begin to use coinage systematically until the conquest by Alexander the Great, although there is some evidence of limited use of coins along the Mediterranean coast, possibly because of contact with Greek traders, during the Persian domination.

### 2.3 *The first coins*

The historical evidence on the origin of coinage is very sparse. The Greeks of mainland Greece are believed to have started coining silver around the mid-6th century (Kroll and Waggoner 1984). The earliest coins found in a datable archaeological context are the electrum coins of Asia Minor, found in Ephesos and dating no later than about 560BC. Most scholars agree that coinage began in this area in the late 7th or early 6th century BC. Two elements in the historical record point to Lydia as the birthplace of money: one is a remark by Herodotus that Lydians were the first to use coins of gold and silver: he was writing about 150 years after the fact. A close source is the philosopher Xenophanes, quoted in a dictionary of the second century AD as stating that Lydians invented coinage. Xenophanes was born in Colophon (not far from Ephesos) around 570BC: his testimony is therefore nearly contemporaneous. There is no contemporary evidence on the use of coinage in Asia Minor in the 7th and 6th centuries, except for an ambiguous text discussed below.

### 2.4 *Dating*

The overwhelming majority of known extant coins have appeared through commercial channels, so that they have no archaeological context. Of the few hoards that we know, the so-called Artemision hoard is the most important, although its interpretation has changed over time.

The coins were found during the 1904–05 excavations of the temple of Artemis in Ephesus, more precisely in the foundations of the temple to whose King Croesus of Lydia contributed. Most coins were found dispersed inside a cubic foundation built to support a structure inside Croesus' temple designed to contain the statue of the goddess. The original excavators thought that the structure was an early temple and that the coins

constituted a foundation deposit, but excavations carried out in the 1980s have changed the chronology of structures. The contents of the cubic foundation are now believed to have included sacrificial remnants swept into the foundation of Croesus' temple soon after his accession in 560 BC (Bammer 1990, 150). This provides a *terminus ante quem* for coinage, but the coins could have been deposited in the course of sacrifices for an extended period of time, and do not constitute a hoard, in the sense of a collection of coins assembled by a single person at a point in time.

Supporters of the late chronology tend to focus on the *terminus ante quem*, but other evidence from the Artemision suggests that coinage must have started earlier. The early excavators found another set of coins, the so-called "pot-hoard," inside a simple clay pot placed just above the level of a flood dated to the 7th century (Karwiese 1991). The pot itself, an everyday jug with a broken handle and a hole in the base, has been dated on stylistic grounds to 650–625 BC (Williams 1991–1993, 101), and it is unlikely that such a pot would have been kept very long before being used as recipient of the hoard.

Furthermore, the recent excavations have recovered additional coins around cult bases surrounding the pre-Croesus sanctuary. One coin, in particular, has been found in a layer of sacrificial remains dated to 630–615 BC (Kerschner 1997, 181, 226; see Seipel 2008, 238–244 for the most recent coin finds). Put together, the evidence from the Artemision indicates that electrum coins were in use between 630 and 560BC.

Why is this important? Essentially the vast majority of types are represented in the Artemision hoard, including the most primitive types. Hence the birthdate of money, and its birthplace, cannot be too far away from 600BC Ephesus.

Aside from a few stray items in Thrace, Macedonia, and Crimea, all known finds are, like that of Ephesus, from locations in Asia Minor (Western Turkey). (ICGH).

### 3 Physical evidence

#### 3.1 *Coin weights and standards*

What makes these objects coins, rather than mere lumps of metal (some of which were also found in the Artemision deposit) is a set of characteristics that they share.

One characteristic is their weight. Figure 2 plots a histogram of the logarithm of early electrum coin weights. The sample of coins, over 2500 in number, is taken from various museum and private collection catalogues, as well as the websites [www.cngcoins.com](http://www.cngcoins.com) and [www.CoinArchives.com](http://www.CoinArchives.com) which document coins sold in the numismatic trade

since about 2001. The weights are shown on a logarithmic scale. The graph shows two things: (1) coin weights cluster at regularly spaced intervals (shown as vertical dotted lines in the figure), and (2) the intervals align themselves on at least two distinct series.

Numismatists recognize the clusters as denominations and the series as standards, named after the cities or areas whose coinage is believed to have followed them. The weights indicated for each standard correspond to the typical or modal weight of the largest known denomination, and is not derived from any information external to the coins themselves.<sup>1</sup> The standards are few: three have been recognized, the most common has been called the Milesian or Lydian-Milesian, with its largest unit around 14g or 15g. Another (at around 17g) has been named Samian, because certain series on that standard are associated by type or find location with the island of Samos. A third one (at around 16g) has been called Phocaic, because the later mintage of the city of Phocaea continued on that standard. These last two standards are hard to distinguish on the figure.

Within each standard the largest unit is conventionally called the stater, following the classical Greek usage.<sup>2</sup> The denominations are clear subdivisions of the stater: the third (or trite), and subdivisions of the third by powers of 2 ( $1/6$  or hekta,  $1/12$  or hemihakta,  $1/24$  or myshemihakta,  $1/48$  and  $1/96$ ; possibly even  $1/192$ ).

The Milesian standard's denomination structure is slightly different from the others. The halves are quite rare, but the thirds or trites are preponderant (19%). Conversely, the trite is wholly absent from the the slightly heavier Phocaic and Samian standards.

Figure 3 shows the distribution of coin weights around each denomination for the coins in the Milesian standard, and Table 1 provides some summary statistics. The coins are sorted into denominations by bins equally spaced between the modes of the clusters. Even with this rough classification, it is apparent that the coins were made rather precisely, although the precision decreases with the coin size. In the case of the

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<sup>1</sup>Curiously, the Milesian and Phocaean standards, the most common ones, do not correspond to any known unit of weight. To the East, Assyria and the Middle East used a shekel of about 8.5g (Fales 1997), as did Phoenicia along with two other shekels of 9.5g and 10.5g, while to the West, the Greeks later used for their coinage either the Euboic standard of 17.4g to a stater (very close to two Babylonian shekels) or the Aeginetan stater of 12.4g (Kroll 2001a, 80,82). Wallace (2001) links the 14g Milesian stater with the 7g shekels of 5th c. BC Phoenicia: Lydia would have adopted as standard a hypothetical double shekel. This (aside from the chronological gap) seems unconvincing given the scarcity of half-staters and prevalence of the third-stater and its subdivisions in the early electrum coinage.

<sup>2</sup>An inscription found in the excavations of the temple of Ephesus documents payments in and out of the treasury in gold and silver. The inscription seems to date from before 550BC, and measures quantities in minae, a unit of weight, but also in staters and sixths of staters (hektes). It is not clear whether these staters and hektes are coins or weights (Manganaro 1974).

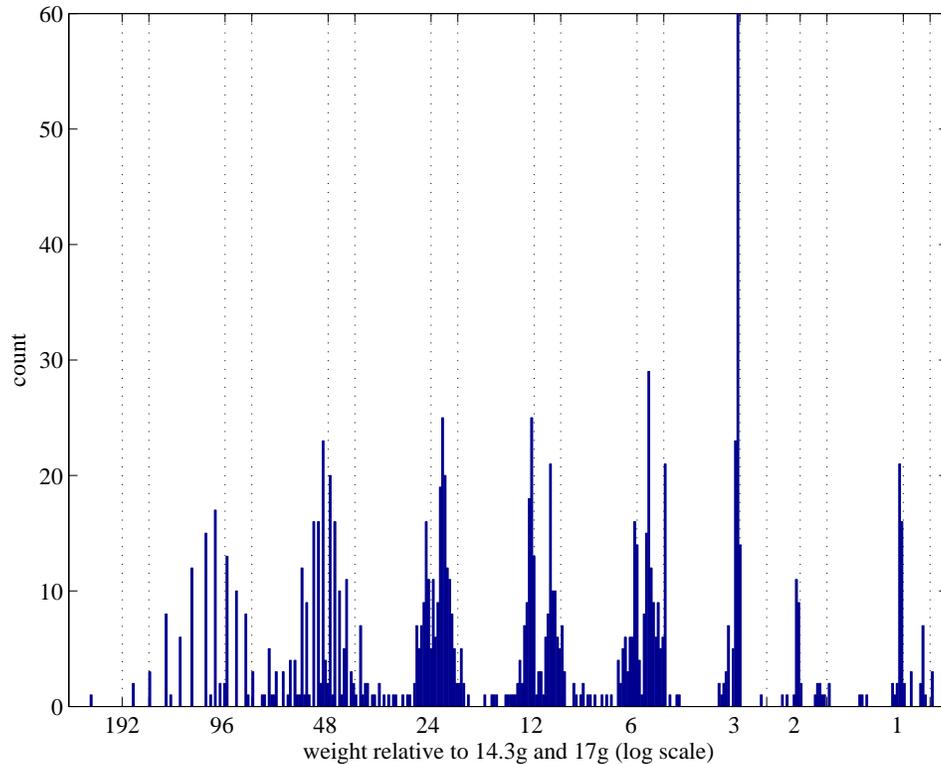


Figure 2: Histogram of early electrum coin weights, log scale.

royal trites (which account for three quarters of the trites in the table), the coefficient of variation is less than 1%. It should be kept in mind that the standard deviation of the weight of coins that have circulated can be quite a bit larger than their original standard deviation (for 19th century coinage, the increase can be a factor of 5 after 50 years).

### 3.2 *Coin types*

Another characteristic shared by all surviving electrum coins is that the *reverse* of the coin bears the incuse (concave) mark of one or more geometric die: either square or rectangular, sometimes with designs inside. As for the *obverse*, it is sometimes blank, presenting only a smooth or striated surface, or else it shows a design in relief: geometric, floral, animal, human or mythological. Thus, coins can be classified into series based on types (obverse and reverse design), and individual coins or series can be linked together by linking dies, that is, recognizing that the same die (obverse or reverse) has been used to strike two coins.

denomination	96	48	24	12	6	3	2	1
<i>all coins</i>								
number	103	243	329	383	273	341	44	92
mean weight (g)	0.14	0.29	0.59	1.17	2.38	4.68	7.19	13.88
coefficient of variation (%)	22.77	14.79	9.17	8.92	8.97	3.12	6.11	4.90
<i>royals</i>								
	5	12	13	103	32	268	-	-
	0.15	0.28	0.61	1.16	2.34	4.71	-	-
	8.2	9.46	9.8	5.39	2.65	0.91	-	-

Table 1: Summary statistics of coin sample by denomination, Milesian standard.

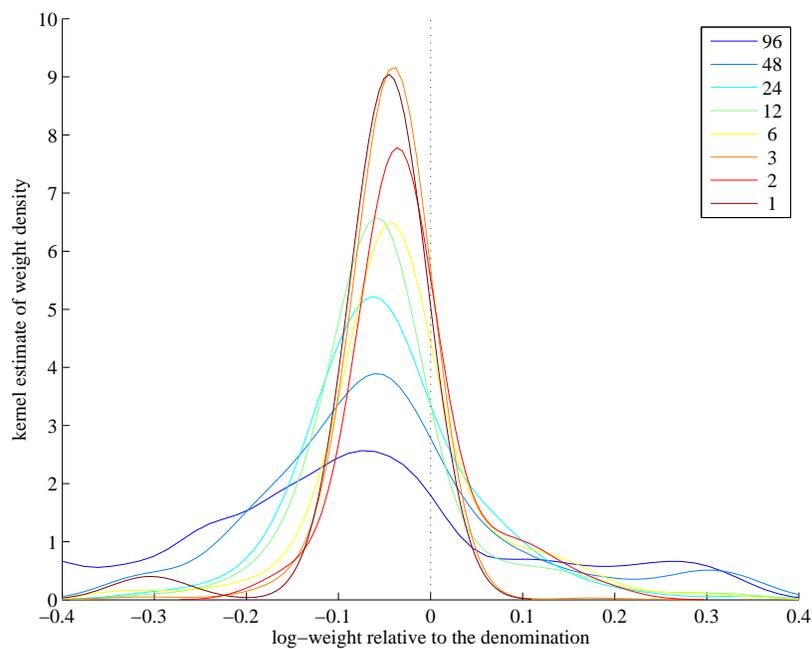


Figure 3: Smoothed distribution of coin weights around each denomination (Milesian standard).

Starting with the reverse types, numismatists have noted that the largest coins and their subdivisions from halves to sixths have different patterns of reverse punches, as shown in Table 2.

Le Rider (2001, 45, 51) has emphasized this system of reverse punches as creating a

standard	weight	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{6}$	$\frac{1}{12}$ — $\frac{1}{48}$
(Lydo-) Milesian	14.0–14.3	■ ■	■ ■	■■	■■	■
Phocaian	16.2–16.5	■■			■	■
Samian (Euboic)	17.0–17.5	■■	■ ■		■	■

Table 2: Weight standards and pattern of reverse punches.

clear set of standards, delineating what seemed to him like monetary unions extending over geographical areas, particularly for the Milesian standard (to which 70% of surviving coins belong). He hypothesized that the first coins, those with blank obverse, were issued under an agreed standard by various states, and the idea of distinguishing each state's issue with obverse types followed later. It should be noted that the classification is far from perfect: Le Rider (2001, 45) himself noted a few exceptions among sixths and halves, there are quite a few more, particularly among coins with blank obverse.<sup>3</sup> Also, the Samian and Phocaic standards, which are very close, are only distinguished for the largest coin, arguably the easiest to distinguish: all other denominations in both systems have a single square punch. Furthermore, in all three systems the denominations from  $\frac{1}{12}$  down have a single square incuse on the reverse: presumably the small sizes made it impractical to put anything else on the reverse, and it may also be the case that below a certain size the differences did not matter much.

Further classifications can be made on the the basis of the obverse dies.

In her ground-breaking study, Weidauer (1975) distinguished fifty series (hereafter referenced by their roman numeral), of which forty on the Milesian standard. Since then, many coins have been appearing in the numismatic trade, presumably from discoveries made in Turkey, and the known types number close to a hundred (Konuk

<sup>3</sup>Weidauer 119 and 141, Milesian hektes with single punch; Rosen 250 and 251, hemistaters with single punch. Additional exceptions to the rule include: Berlin 18200915 is a type-less Samian stater with a single square punch; BMC 1895,0302.1 is a Milesian stater with single square punch; New York ANS 1956.183.21 and 1967.152.431, Berlin 18200104, Milesian hemistaters with a single punch; GC16p2.3, a Milesian hemistater with the punches of a stater; Weidauer 35, 50, Rosen 258 and GC16p3.10 (Pegasus protome) are Milesian hektes with a single punch. Recent numismatic sales have revealed other exceptions: the coins in Triton VIII/438-440, CNG 69/428, CNG 73/339 represent a series of blank Samian staters, halves and fourths with a bipartite incuse square punch on all denominations. Punches that are neither square nor rectangular are also known: GC16p116.1 (Milesian hemistater with stellate flower) has a cruciform punch, Berlin 18200105 (Phocaian hemistater with Gorgon head) has a star-shaped punch, and Aulock 1792, 1793; Haykan 691; GC16p15.72 (Samian twelfth) have a circular punch and Triton VII/243, 245, and 246 (blank Samian stater and hemistaters) have an ornamented circular punch. Conversely, GC16p183.1 is a striated stater with the punches of the Milesian standard, but weighs only 10.8g.

forthcoming). Archaeological discoveries are quite rare, and the few hoards that have been found only give a hint of chronology between the series. A few series can be securely identified as emanating from specific Greek cities because the design reappears in clearly recognizable form in later silver issues of the 6th and 5th centuries: this is the case for Miletus, Ephesus, Samos, Phocaia. But the vast majority remains unidentifiable and feature a wide variety of designs. It is also particularly difficult to identify the types of the smaller denominations because of their size.

Within the Milesian standard one group of series (Weidauer XIII–XVIII and Karwiese I) stands out, first because of its importance (about 24% of the Milesian coins), is traditionally attributed to the kingdom of Lydia, because two series bear inscriptions in the Lydian alphabet, and other distinct series are die-linked to the former. I will call these the “royal” coins. The most frequently encountered coins in this group (Weidauer XV) show a lion head in profile with a distinctive “wart” or globule on the lion’s forefront (Figure 4), or else two confronted lions’ heads; the smaller denominations (die-linked to the former) show a lion’s paw. The lion was a common royal symbol in the Middle East and was particularly tied in Lydian legends to the royal family; the globule on the forehead is a peculiarity whose meaning is unknown but which is attested in Assyrian and Babylonian art from the 10th to the 7th c. BC (Robinson 1951). The use of the lion, however, was not exclusive to these series; another series featuring a reclining lion looking back is attributed to the city of Miletus because this device remained in its coinage long after, and several other series or individual pieces show lions that are artistically quite distinct from the Lydian image.<sup>4</sup> Nor was the lion with wart or globule the only device used in the Lydian group: a type with boar’s head and another with the forepart of a lion (Weidauer XIII and XIV) are die-linked to the royal coinage (Spier 1998, Seipel 2008).

The inscriptions (Weidauer XVII and XVIII) are both varied and difficult to interpret. The most common one, long read as *valvel* or *walwel* (Weidauer XVII), is now thought to be *walwetalim* (FAAFETAAIM). This, given the sparse knowledge of the Lydian language, could mean “of (belonging to) Walwetas”, which in turn could

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<sup>4</sup>See Weidauer XIX, so-called linear or “barbarian” lion head; Weidauer XXIII–XXVI, with scorpio in the reverse punch, attributed by Konuk to Caria; Weidauer XXXI–XXXII, facing lion-head on Milesian standard, Weidauer XLIII, lion-head on Phocaian standard; Weidauer L, facing lion-head on Samian standard. See also the spectacular lions affronty on a Milesian stater of the British Museum (1895,0302.1).



Figure 4: A trite of the royal series (author's collection).

plausibly refer to the king known to Greek historians as Alyattes (610–560 BC). But other coins, die-linked to the walwel-series, bear other names. One lion-head series (Weidauer XVIII) bears *kukalim*, as read by Browne 2000 and Wallace 2006, or *krkalim* as read by Karwiese 2008, 138. This would mean “of Kukas/Krkas” which some have interpreted as referring to King Gyges, who reigned a generation or two earlier, or to Croesus, who reigned later.<sup>5</sup> Another inscription, found on the boar head coins which are die-linked to the walwel series, has been read variously: Bammer (1988, 18) sees *t v e*, Spier (1998, 333) sees *l(?) a t e*, and Karwiese (in Seipel 2008, 240) sees *F e t a* which is compatible with *walwetalim*.<sup>6</sup>

The only other electrum coins featuring inscriptions form the so-called “Phanes” series (Weidauer VIII), with the design of a stag, in which the larger denominations bear a Greek inscription reading either “I am the sign of Phanes” (staters) or “of Phanes” (trites). These coins are attributed to Ephesos, because the stag was the sacred animal of Artemis, and because it reappears in the same position on later, well-identified issues of that city. There is no consensus on whether Phanes is the name of an individual or refers to Artemis.

Aside from the multiplicity of inscriptions, the bewildering variety of types that appear together in hoards suggests that no single issuer enjoyed any kind of monopoly on coin issue in Asia Minor at the time. The few hoards we have even contain mixes of coins of different standards. The contents of the Artemision central basis contained mostly coins on the Milesian standards, but also several coins of Phocacia.<sup>7</sup> The Priene

<sup>5</sup>The name of Gyges appears in Assyrian documents as “Gugu” (Spalinger 1978). The name of Croesus is known to us only in its Greek transcription.

<sup>6</sup>(Karwiese 1991, 9) had earlier claimed that other coins bear inscriptions that are neither *walwetalim* nor *krkalim*.

<sup>7</sup>One griffon-head, Head 85, and two seal-heads, Head 86 and 87 (Bodenstedt 1981, 46). Also found in the Artemision excavations, in an unknown location, were three beetles probably on the Samian standard

hoard (IGCH 1157, Spier 1998) contained three Samian and four Milesian coins; CG IX.341 contained 7 Milesian coins and 14 Samian coins.

### 3.3 *The coins' metal content*

What alloy did these coins contain? This has been a vexing question for decades.

#### *Gold and silver before coinage*

Gold has been used to make jewelry for a very long time: the earliest archaeological evidence for the use of gold on any scale appears in a late 5th millennium cemetery in Bulgaria. Mesopotamian gold is generally assumed (without hard evidence) to have come from Egypt, the Eastern Desert and Nubia (Muhly 1993, 123). References to different qualities of gold, with different prices in terms of silver, exist as early as the end of the 3d millennium (Young 1979, Waetzoldt 1985).

Silver was first used in the 4th millennium in Near East and Europe. Mesopotamia did not have its own sources of silver, but had to acquire it by trade or tribute from neighboring regions. Lead isotope analysis suggests that early silver came from the Taurus mountains (Muhly 1993, 130) but further analyses have also suggested sources in Iran and in the Aegean (Stos-Gale 2001).

It is well known from surviving clay tablets of Mesopotamia that silver was frequently, and by the 1st millennium almost exclusively, used as unit of account in expressing prices, although gold seemed to be used for a period of time in the middle of the 2nd millennium (Powell 1996). By the time of the Neo-Assyrian and Neo-Babylonian empires (9th to 6th c. BC), the common form of expressing prices was in quantities of the good equivalent to one shekel (8.4g) of silver (Slotsky 1997).

To what extent was silver used as a medium of exchange is harder to assess. The most striking evidence comes from silver hoards of the Near and Middle East. Long considered to be silversmiths' hoards, they are now seen as normal hoards. They become particularly abundant in the Fertile crescent after the 11th c. BC, and a number have been found in the Near East. Some are quite substantial: the Tel Dor hoard (late 11th-early 10th c.) contained 8.5kg (Stern 2001, 21), the Eshtemo'a hoard (10th c. BC) 28.055kg, the six Tel Miqne hoards (7th c. BC) totalled 1419g. Other hoards of same period are in the 1-1.5kg range (Gitin and Golani 2001). The Eshtemo'a hoard in Israel

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(see Triton VIII/453, IX/952, Rosen 353, Falghera 150). The same type was found in the Colophon hoard (CH IX.336) mixed with mostly Milesian standard coins (Spier 1998, 328).

contained silver ranging from 78 to 97%; Sechem hoard from 71% to 92% (Vargyas 2001-, 48).

In Neo-Assyrian sources, until 700BC the quality of silver is not mentioned, but refined silver is specified in a text from 702BC. The standard silver is 87.5%, attested in the first quarter of the 7th c., but other grades of fineness are attested: 91.7% (between 605 and 579BC), 83.3% (599BC), 80% as the silver used in trade (572–562BC) (Vargyas 2001-, 18, 34–37, 47)

### *The technology for recognizing and separating metals*

The traditional technology to determine the fineness of precious metals in early times, aside from inspecting the color and sound, is the touchstone. An object is assayed by rubbing it against the touchstone and comparing the resulting streak with the one produced by a sample of known fineness. Theophrastus, in the early 3d c. BC, says that gold could be assayed within a sixth of a carat. This, of course, presumes that a set of samples of known fineness is on hand; and that one is dealing with a binary alloy. The touchstone is attested in Greek texts as far back as the 6th c. BC and often called “the Lydian stone”; but the technology is clearly far older. A silversmith’s hoard, found in the ruins of Larsa (Mesopotamia), and dated to 18th century BC, contained a small piece of hematite. The archaeologists, unsure of its purpose, showed it to a goldsmith in the local souk: he immediately recognized it and pulled out his own very similar touchstone from a drawer (Arnaud et al. 1979, 20, cited in Le Rider 2001, 14).

It is easy enough to mix gold, silver, copper and other metals: all that needs to be done is melt them together, and the necessary temperature (between 1000° C and 1100° C) had been achievable for millennia. Separating the metals once they are alloyed is another matter.

Gold and silver can be separated from the base metals (such as copper) by cupellation: the alloy is melted together with lead under a strong air flow: lead oxidizes and forms lead oxide or litharge which also captures the oxides of other base metals, leaving the “noble” metals, gold and silver, separate. The earliest evidence for the process comes from 4th millennium Uruk (Muhly 1993, 130). It seems clear that the references in Babylonian sources to the purification of gold relate to its separation from copper (Le Rider 2001, 12–13).

Separating gold and silver requires another process. The one used in ancient times is called parting. Gold is prepared into small pieces or thin strips and mixed in layers with salts and brick powder. The mixture is then heated to between 500° C and

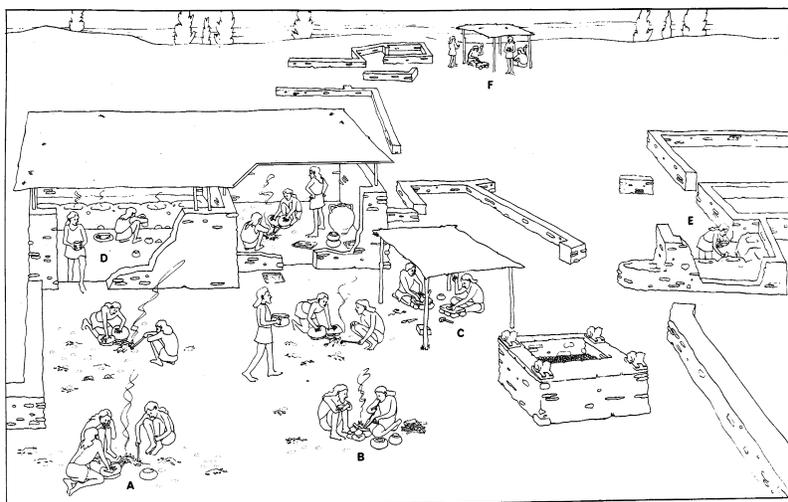


Fig. 10. Reconstruction of Lydian industrial area by E. Wahle.

Figure 5: A reconstruction of the cementation technology at Sardis, c550 BC.

800° C (below the melting point of gold) and the silver reacts with the salt to produce silver chloride. The diffusion process takes place throughout the gold which remains unmelted. The silver chloride is absorbed in the brick powder and in the clay vessel that contains the mixture, if it does not escape. Once the purified gold is removed, the remainder can be ground up and some of the silver retrieved by cupellation.

The question is: When did this technique become available? The process was known in later antiquity (see the surveys by Barrandon and Poirier 1985b and Craddock 2000) but the earliest archaeological evidence appears in a workshop excavated in Sardis, dated to around 575–550BC. Figure 5 shows a reconstruction of the workshop. This, not coincidentally, is the time period during which Croesus is believed to have begun the minting of gold and silver coins.

Short of direct evidence for the parting process before that time, one can look at the golden objects made and used, and see if they show any consistent evidence of purification. Craddock (2000) shows that gold objects in early Mesopotamia were burnished, presumably with some sort of salt, so that the surface was depleted of silver and appeared pure. At a minimum, this suggests that people were aware of the mixed nature of electrum, and valued purer gold over more diluted gold. But, aside from occasional objects showing a high content of gold (for example, a few objects in the Troy II hoard with 93% gold cited by Keyser and Clark 2001), it does not appear that, at any time before 6th c. Lydia, gold was systematically separated from silver. Conversely,

the gold coinage of Croesus is made of 98% gold, and the gold beads and foil found in the goldworks of Sardis are similarly pure.

### *The available metals*

The richness of Lydia in precious metals was well-known in antiquity. The gold of Gyges, the founder of the Mermnad dynasty of Lydian rulers, remained legendary for centuries. The gold originated from Mount Tmolos, which dominates the river plain where Sardis is located, at the junction of the Pactolos and Hermos rivers. The Pactolos was famous for its alluvial gold, and Greek legend held that the Phrygian king Midas had washed away his gift for turning objects into gold in the Pactolos river. Gold was also mined, although we do not know how early, and by the early 1st c. AD when Strabo (14.5.28, 13.1.23, cited in Waldbaum 1983, 13) wrote, the alluvial gold as well as the mines were exhausted.

The gold of Mount Tmolos, like most placer gold, was in fact a natural alloy of gold and silver, with a little copper. This alloy has been called since ancient times electrum, a Greek word originally applied to amber.<sup>8</sup> How much gold was contained is not known with certainty. Until recently, the only analysis of alluvial gold from the Sardis region was a sample of gold panned from the Pactolos river, which was determined by neutron activation to contain 17 to 24% silver (Hanfmann et al. 1970, 27). Excavations in the area of gold works of Sardis have yielded two small granules which appear to be alluvial gold, were found to contain 69.6% Au, 29.8% Ag, 0.6% Cu in one; 83.3% gold, 16.2% silver and 0.5% in another (Meeks 2000, 148). The analysis of samples of alluvial gold from other regions of the world are summarized in Barrandon and Poirier (1985a, 35) and Morrisson et al. (1987, 208–209). Mostly, the amount of gold is within a 80–97% range, with a few examples (especially in Rumania) in the 60–70% range. The copper content of alluvial gold can be as high as 0.9%.

That electrum was not pure gold was well-known. Mesopotamian sources make distinctions between different grades of gold (Muhly 1993, 122–3), and Herodotus (1:50) tells the story of gifts made by King Croesus to the sanctuary of Apollo in Delphi, which included ingots of pure gold (ἄπεφθός χρυσός, literally “boiled gold”) weighing 2.5 talents each, and ingots of gold-silver alloy (λευκός χρυσός, literally “white gold”)

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<sup>8</sup>Amber was already prized at the time: carved amber has been found in the excavations of the Artemision.

of same size and weighing 2 talents each. Assuming that there is no other component metal, it is possible to infer the composition of Croesus' white gold. The proportion is

$$\chi = \frac{\frac{SG_{Au}}{SG_{Ag}} - \frac{SG_{Au}}{SG}}{\frac{SG_{Au}}{SG_{Ag}} - 1} \quad (I)$$

with  $\frac{SG_{Au}}{SG_{Ag}} = 1.838$  and  $\frac{SG_{Au}}{SG} = 1.25$ , or  $\chi = 0.7$ .

### *Analysis of the early electrum coinage*

For a long time, the only non-destructive analysis consisted in measuring the specific gravity of the coins. Such measurements had been made in the 19th century, and Hammer (1908) had noted the wide range of implied gold-silver compositions.

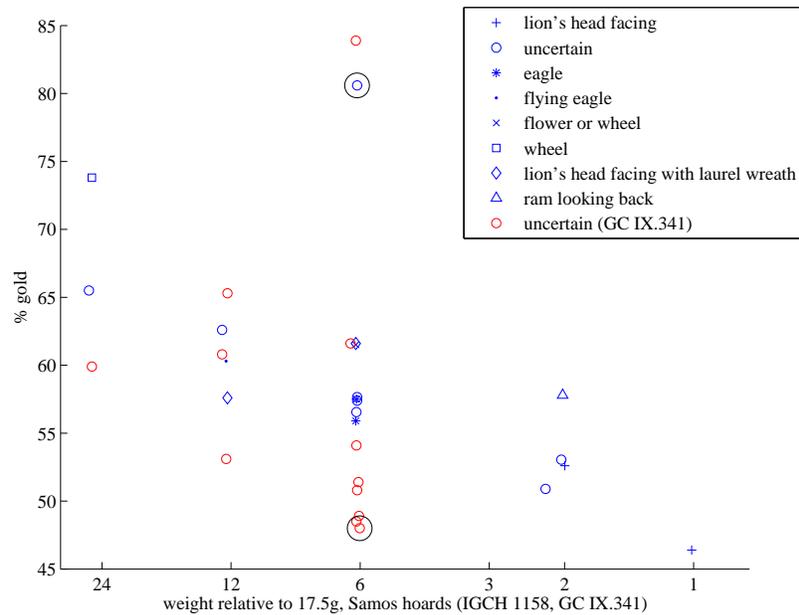


Figure 6: Gold content of the Samos hoards as function of weight and type.

The modern non-destructive analysis methods that have been used since the 1950s on electrum coinage rely on exciting the atoms of the coin and measuring the response. They fall into two broad groups. I first describe the methods and then present the existing results.

One group, called activation analysis, irradiates the sample and measures the emitted radiation, which will be specific to the elements present, and in proportion with their

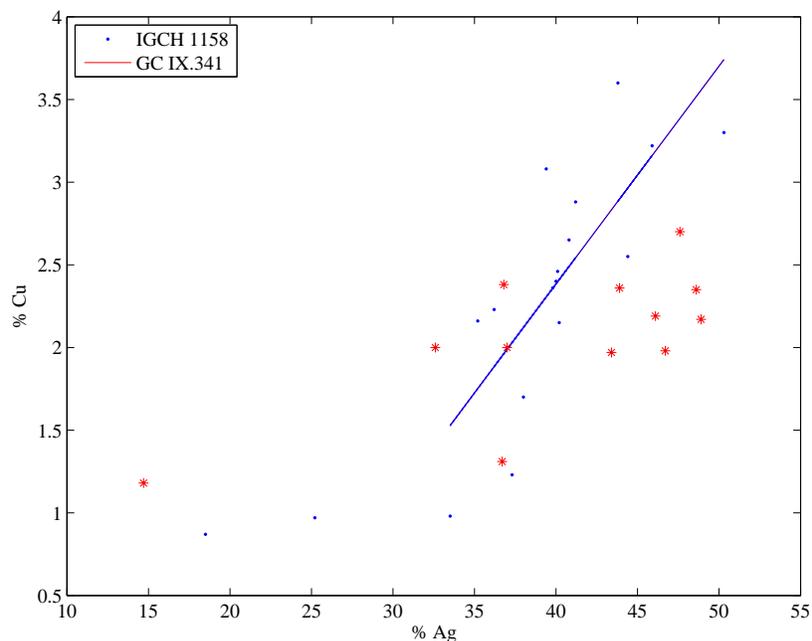


Figure 7: Silver and copper content of the Samos hoards.

quantities. The activating particles can be neutrons (NAA), or fast neutrons (FNAA), or protons (PAA). Because of interferences within the sample, NAA requires taking samples or streaks, and cannot detect some elements (Pb, Bi). FNAA uses lower energy particles and allows analysis of the bulk of the coin (half of the beam of particles is absorbed after 37mm). PAA avoids interferences and can penetrate up to 340  $\mu\text{m}$ . The drawback of activation analysis is that it requires a nuclear reactor, and several days must pass before measurements are taken.

The other group of methods is based on exciting the sample with photons (X-ray fluorescence, XRF) or electrons (scanning electron microscope, or SEM) and measuring the rays emitted by the excited atoms. The method is cheaper and faster, but does not penetrate much below the surface of the coin (5 to 50  $\mu\text{m}$  only), which can lead to mis-measurement because of alteration of the surface over time. It is also less sensitive, and cannot easily detect trace elements.<sup>9</sup>

<sup>9</sup>The difference between wavelength dispersive (WD-XRF) and energy dispersive (ED-XRF) is in the method of reading the fluorescence, sequentially in the first case, all-at-once or multi-elemental in the second. The former, however, has better spectral resolution by one order of magnitude (Northover 1998, 96). SEM (scanning electron microscope) bombards with electrons rather than X-rays, but creates background radiation that limits detection compared to PIXE and XRF.

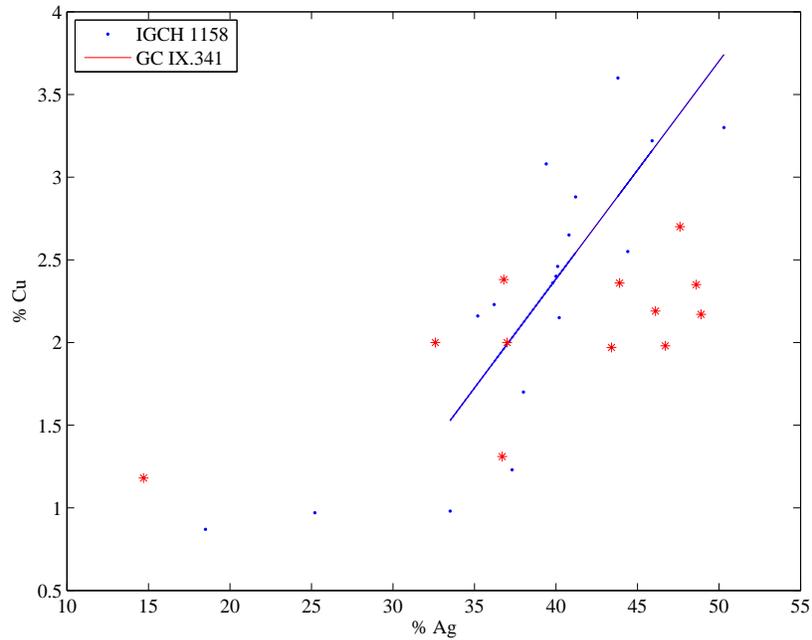


Figure 8: Silver and lead content of the Samos hoards.

Either method has shown conclusively that the early specific gravity measurements were flawed. It works in principle only for binary alloys, and the common presence of copper as a third alloy distorts the calculations. It also appears that coins are not solid mass, but can contain empty spaces or bubbles, which again distorts the calculations.

One particularly interesting set of measurements by PAA was carried out by Nicolet-Pierre and Barrandon (1997) on the contents of the Samos hoard, discovered in the late 19th c., most of whose contents were acquired by the Paris Cabinet des Médailles and the British Museum. The hoard (IGCH 1158) contained over 60 electrum coins, in a variety of types and denominations, although all on the Samian standard. Another hoard, found in 1998 on the mainland facing Samos (CH IX.341), was very similar in content and analyzed by Konuk (2005), also by PAA.

One main result of the analyses appear in Figure 6: within the hoards, there is wide dispersion in gold content of the coins, ranging from 45% to 85%. There is no discernible pattern of dispersion by type (whereby some types would show more dispersion or have higher mean content), and there is dispersion within types. Indeed, as Konuk (2005) noted, some coins of the 1894 hoard can be die-linked to coins of the recent hoard, and in one instance, the two die-linked coins, presumably from the same workshop, contain 48% and 84% gold respectively.

Another result appears in Figure 7 and Figure 8, namely a non-linear relation between silver content on one hand, and copper or lead content on the other hand. For low levels of silver, the copper or lead content is low and stable; for higher contents of silver, the copper and lead contents increase linearly. This is strong evidence that, up to 35% silver, the alloy was natural, but above 35% silver was added, with inevitable impurities of lead and copper (the copper may have been added to maintain a yellowish color of the alloy).

Cowell et al. (1998) and Cowell and Hyne (2000) summarized and extended analyses of various electrum coins, mostly by XRF. The results (Figure 9) confirm the variability of gold content, show no pattern as a function of weight, but suggest that the gold content of the royal coins varied in a smaller range, from 50 to 60%. Unfortunately the sample is relatively small.

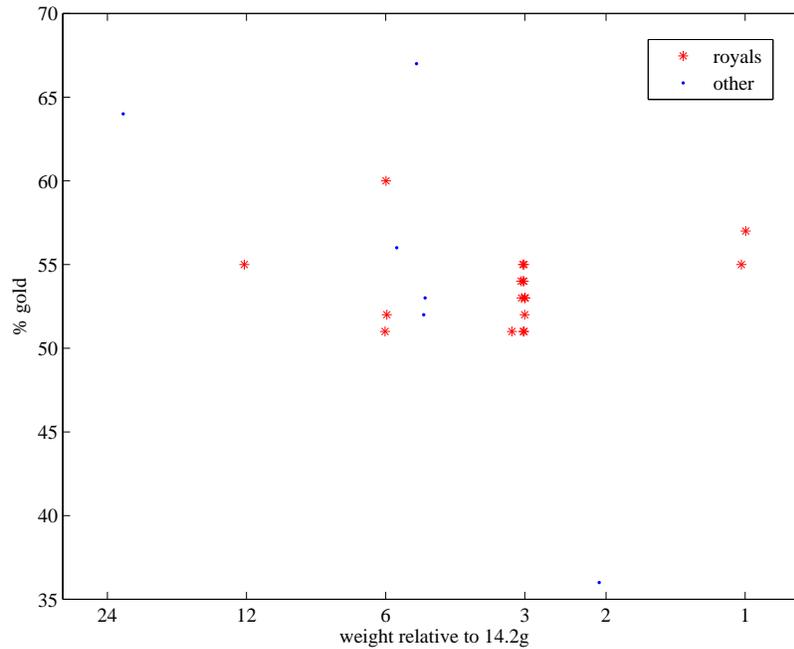


Figure 9: Gold content of various electrum coins (Cowell and Hyne 2000).

Finally, a large and varied collection of coins, the Falghera collection in Milan, was analyzed by XRF by Avaldi et al. (1984), and the complete results, published in Vismara (1993, 76–83), are shown in Figure 10 confirm in a spectacular fashion the wide dispersion in gold content, ranging from 35% to 85%. It seems that the dispersion decreases with denomination size, and it also seems that the gold percentages of royal coins are more tightly concentrated than the whole sample (Figure 12). But there are discrepancies between these results and earlier ones. The fineness of the Lydian coinage is markedly higher than found by Cowell and Hyne (2000). The relation between silver and copper content found by Nicolet-Pierre and Barrandon (1997) is not confirmed. Cowell and Hyne (2000, 172) note a much higher discrepancy between SG measurements and XRF measurements than is usual. Finally, the results published in Avaldi et al. (1984) for a third of the collection do not match the numbers in Vismara (1993).

No other large-scale analysis of early electrum coinage has been carried out so far. A third method is based on taking small samples through laser ablation (LA), and inserting it in a plasma (inductively coupled plasma, or ICP); the quantities of elements present are then measured by mass spectrometry (MS) or atomic absorption spectrometry (AAS). See the contributions in (Oddy and Cowell 1998) for an overview. A project is underway to apply LA-ICP-MS to electrum coinage on collections in Paris and New York. One interesting (preliminary) finding from these analyses appears to be that the royal coins were made with a precise fineness:  $55 \pm 2\%$ . This suggests that the Lydians were quite capable of controlling the fineness of their issues.

- a third technique involves ablation of a micro-sample by laser, insertion into a plasma, and spectrometry (mass or absorption)
- laboratory at Orléans currently carrying out analyses on electrum coinage
- preliminary result: the Lydians controlled the fineness of their coinage to  $55 \pm 2\%$

### 3.4 *Circulation*

Evidence of wear (Bellinger 1968, 13). Bankers' marks. These marks appear mostly on the coinage of Lydia (thirds and twelfths), and singularly on the coins with lion head and sun with multiple rays (Weidauer XVI).<sup>10</sup>

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<sup>10</sup>There are nevertheless a few examples of coins without obverse designs bearing bankers' marks (CNG, EA203, lot 139 and EA160, lot 65, hemihektes).

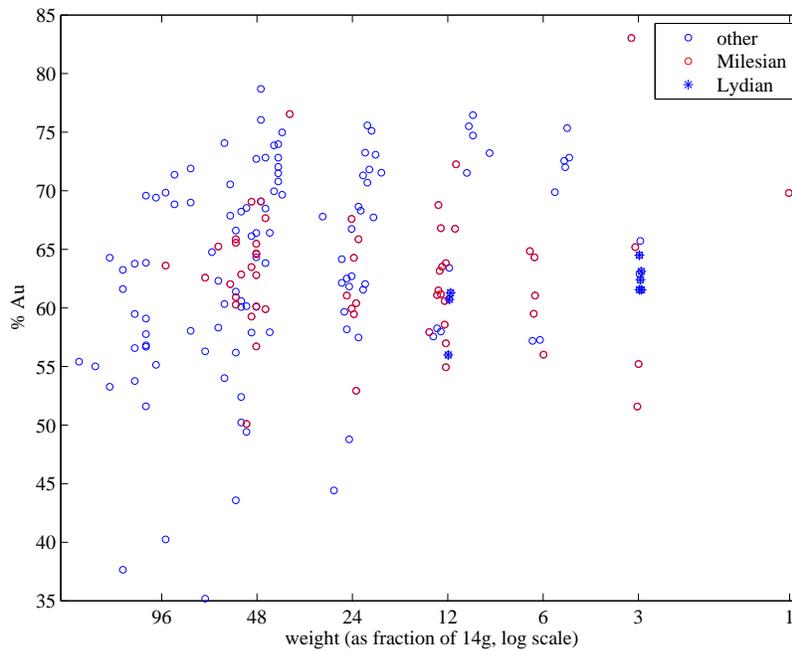


Figure 10: Gold content of electrum coins in the Falghera collection (Vismara 1993).

### 3.5 *Wear on electrum coins*

Figure 3 shows that the distribution of weights of electrum coins shifts to the left for lower denominations.

Figure 14 shows a linear relationship between the log of denomination and the extent of this shift, highly reminiscent of a similar relation for 18th c. and 19th c. coinage. In the latter case, coins are dated and it is possible to prove that this relation is due to the age of coins, that is, to weight loss through circulation. I take the appearance of this relation in the electrum coinage to be indicative of circulation.

The conclusion seems to be that lower mean weights for smaller denominations are typical of circulating coinage, and can be accounted for by the annual weight loss due to increased circulation for smaller denominations. That the early electrum coinage fits this pattern is evidence that it did circulate like modern coinages.

### 3.6 *Purchasing power*

The purchasing power of the early coinage is clearly an important question, yet it has so far received relatively little attention. Price data for the Greek world in this period,

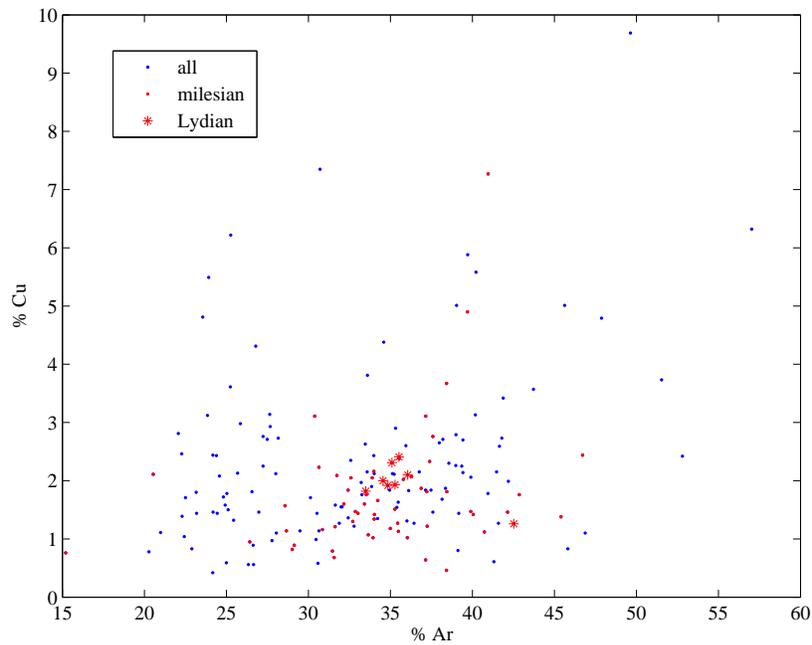


Figure 11: Copper and silver content in the Falghera collection.

before the widespread coinage of silver by the Greek cities, is scarce. Early on Cook (1958, 260) noted a remark by Plutarch on the loss of purchasing power of silver over the ages. He cited the fact that in certain laws of Solon (early 6th c. BC) a sheep was valued at one drachma (which, as a monetary unit, contained 4.3g of silver) and an ox at five drachmae. Whether the laws do go back to the time of Solon is discussed in Kroll (1998, 226–227); even if they do, it is not entirely clear what a drachma is meant, since Athenian coinage began a generation after Solon. Nevertheless it has been accepted that electrum coins were too large for retail trade. A stater of electrum containing 50% gold (worth ten times the equivalent silver) and 50% silver would represent 18 drachmae. As Kraay (1976, 318) noted, the silver equivalent of the smallest electrum denomination (1/96) would have paid a day's wages in 5th c. Athens when silver was more abundant.

It might be instructive to look in another direction, where price data is relatively more abundant. The clay tablets of Mesopotamia contain much information. Table 3 compiles information from Neo-Assyrian and Neo-Babylonian times, up to about 550BC. I compare these prices with those available for mid-14th c. Florence.<sup>11</sup>

<sup>11</sup>For Mesopotamia, the sources are as follows. Vargyas (2001-, 62, 132, 229, 256) has the price of barley ranging from 55 to 421 qa per shekel, with a median of 180 (44 observations), for 604–546BC, and the

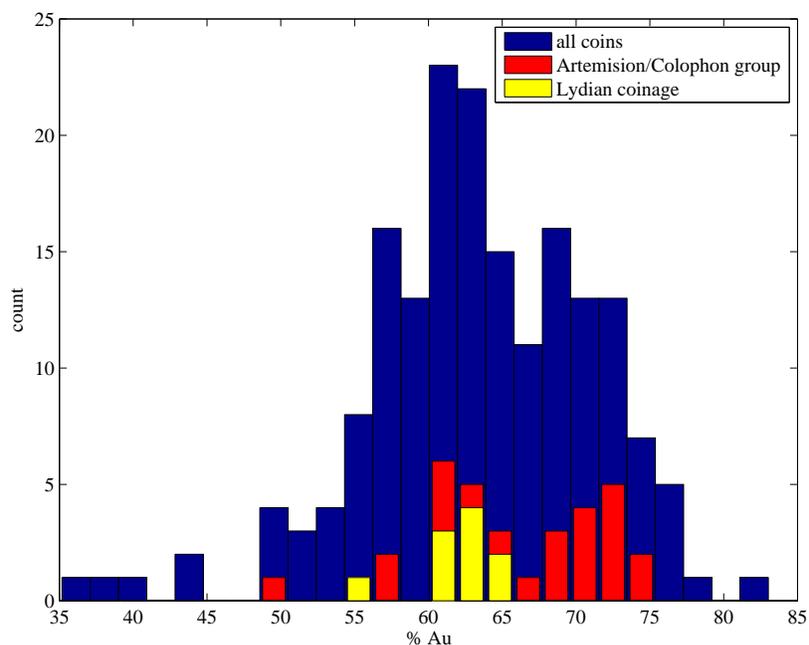


Figure 12: Distribution of gold content across coins in the Falghera collection.

Depending on the item, the ratio of silver prices between 14th century Florence and 600 BC Mesopotamia is between 1 and 5. By that metric, the largest electrum coin was the equivalent of 2 to 10 gold florins, while the smallest coin was similar to a medium-sized silver coin. This suggests that the largest electrum coins could only be used in large commercial transactions, but the smallest coins were not out of range of weekly or monthly purchases. The minimal daily ration for a laborer in 600 BC Babylon was 1.5 liters of barley (Joannès 1997, 321), so the smallest coin (a  $1\frac{1}{96}$  stater)

price dates ranging from 50 to 372 qa for 1 shekel (16 observations), with a median of 225l, for 612–546BC. The price of sesame ranges from 6 qa to 60 qa, with a median of 12 (14 observations) from 604 to 546BC. The ratio of plant to oil is 6:1. Wool ranges from 1.16 to 6.67 minas, with a median of 4, (32 observations), from 636 to 546BC. A qa is 0.84 liter, a mina is 0.5kg, a silver shekel is 8.4g. Fales (1997) has adult male slaves around 90 shekels. Radner (2007) has wages ranging from 1 to 4 shekels per month between 631 and 616 BC, I use the lower end of the range. Dubberstein (1939, 30): 10 to 20 shekels for an ox, 2 shekels for a sheep, 5 shekels to 2 minas for a donkey; 4l of honey for 1 shekel. For Rome, Diocletian's price Edict of 301 AD are published by Giacchero (1974): I use the following prices: barley (1,2), oil (3,4), dates (6,8): the price is 4d for 25 dates, I assume 10g per date and 1l for 1kg), wool (25,9), ox (30,14), sheep (30,18), and a daily wage of 25d (assuming 20 days in a month). The aureus is valued at 1200d, the argenteus (3.2g) at 100d, the small laureate at 2d. For Florence (1325–1376), the median annual average prices for barley is 25.8g silver/hl Olive oil was 230g/orcio (=33.4l). (La Roncière 1982). Sargent and Velde (2002, 48, 51) has a daily wage of 2g silver. Antoni (1966, 49) has wool 8L to 21L per centonaio (100 lb = 33.9kg). Verlinden (1955–77, 2:362) has 40 florins for adult slaves in the 1360s.



Figure 13: Lydian trite with 14 different bankers' marks. Source: CNG, EA236, lot 182 (July 2010).

could feed a laborer for a week.

### *Counterfeiting*

Counterfeiting occurred, and counterfeit coins are sometimes found in hoards (ICGH 1161: a 1/6 and a 1/24, CH 9.336: a lion's paw 1/48). Pászthory (1980) analyzed a hemihekte (1/12) which turned out to be electrum-plated silver, but the counterfeits found in the numismatic trade (1 or 2% of the total number of coins) are frequently plated copper, with no particular pattern in which denominations or which designs are counterfeited.

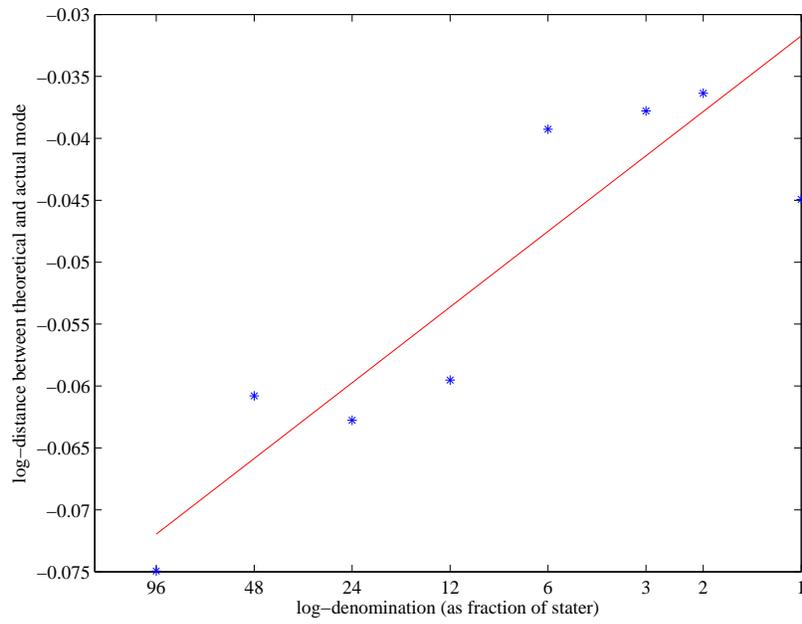


Figure 14: Modes of the weight distributions of electrum coins, by denomination.

### 3.7 *What happened after the first coins?*

## 4 Facts and theories

### 4.1 *A summary of the facts*

#### *preferences*

Gold and silver were durable commodities yielding utility: this aspect of preferences has been a constant through millenia and across civilizations. The relative price of gold to silver was on the order of 10 to 1 in ancient Mesopotamia; numismatists tend to think that it was around 13 in the 6th and 5th c. Greek world and Asia Minor. Moreover, the fineness of gold and silver mattered: for centuries, gold and silver had been rated for their fineness.

	Mesopotamia (g silver)		Rome (g silver)		Florence (g silver)
barley (liter)	0.06		0.11		0.26
dates (liter)	0.04		5.1		
sesame oil (liter)	5.0				
olive oil (liter)			1.40		6.9
wool (kg)	4.2		2.45		2.8
ox	126		160		560
sheep	16.8		12.8		
wage (month)	8.4		16.0		42
adult slave	760				1500
largest and smallest coin					
stater	77	aureus	38.4	florino	37.2
hemihekte	6.4	argenteus	3.2	grosso	1.96
$\frac{1}{96}$	0.8	small laureate	.06	picciolo	.05

Table 3: Price data in Mesopotamia (7th–6th c. BC), Rome (Diocletian’s edict, 301 AD), and Florence (14th c. AD)

### *technology*

Gold and silver were easy to separate from other metals, and easy to mix with each other, but harder to separate from each other. The fineness of gold and silver was detectable, though not very easily. There is clearly a continuum from pure silver through alloys to pure gold: in the case of a purely binary alloy, color alone provides a rough separation, and it takes little training to distinguish alloys of, say, 20% gold and 80% gold. It is true that the addition of copper may make the color harder to distinguish. The touchstone, which allows a very refined distinction of colors, had been known for centuries, and was certainly known in Lydia.

The crucial uncertainty lies in the technology to part gold from silver. It is not firmly attested before 575BC, and may or may not have existed before, when electrum coinage first began.

### *endowments*

Mesopotamia not endowed with either gold or silver, but acquired it by long-distance trade in plentiful quantities. The relative stability of their relative price suggests that trade flows worked smoothly, at least over long intervals of time. Shipwrecks provide

additional evidence for long-distance trade of metals, as do written records of caravans in Mesopotamia.

Lydia endowed with large amounts of a natural alloy of gold and silver, with a probably composition around 70–80% gold.

### *markets*

There is abundant evidence for long-distance trade over millennia. As regards Lydia, it produced desirable goods and services that were exported (there is even a case of export of services, in the form of mercenaries sent to Egypt in 7th c. BC). The Ionian cities were also active trading centers.

### *numeraire and money*

Silver was in use as unit of account for millennia, and as ad-hoc medium of exchange, in the form of *Hacksilber*, for centuries prior to the emergence of coinage. Electrum (gold-silver) coins are the earliest known coins, defined as stamped lumps of metal of standard size. The coins come from Lydia and Ionia, and appear sometime before 630BC, to end around 550BC. There are notable exceptions: a few cities north of Ionia (Mytilene on the island of Lesbos, Phocaia, Lampsacus, and Cyzicus, which continued to coin electrum into the 4th c. BC. Electrum coinage is also found in Carthage and in Celtic Gaul in later periods.

The coins were produced in a broad range of denominations (from 1 to 1/96 or even 1/192). There were many different designs, which could correspond to different issuers, each with a full range of denominations, and these designs coexisted in circulation, as attested by hoards.

The very precise weights of the coins contrast with a highly variable gold content, ranging from 30 to 85% silver. The range of content exceeds natural variation of electrum, hence silver must have been added: the evidence from impurities (copper and lead) leaves little room for doubt.

The purchasing power of largest coin was very large, but smallest coin was equivalent to a few days' wages.

The coins apparently circulated: the distribution of weight is consistent with patterns observed in 18th c, Europe, whereby smaller denominations suffer greater annual losses in weight. The bankers' marks, particularly present on the Lydian coinage, on small as well as large denominations (1/12 to 1/3) are also suggestive of repeated circulation.

## 4.2 *Questions*

Theories of money have always emphasized recognizability as a key element of the material chosen to serve as medium of exchange. Yet the first coins ever produced were made of a material that seems particularly unsuitable for coinage: its natural intrinsic content was variable and was apparently diluted by the first emitters. At the same time, great care was taken to ensure consistency in weights, and the markings of these coins seemed designed (at least for the reverse punches) to establish a recognizable scale of uniform denominations.

Why did these first issuers choose such an unsuitable material, as opposed to silver, which had long been in use as unit of account and, in non-standardized quantities, as medium of exchange? Did the first issuers dilute the content voluntarily, and to what end? Why do some coinages, such as the Lydian coinage, seem to maintain a relatively constant proportion of gold, around 55%, while others did not? How could coins of such different contents circulate at the same time, and be hoarded together? And who were these first issuers: was it a single state, was there competition among states, or were the issuers private individuals? Why didn't Gresham's Law or basic incentives operate quickly to dilute the content of all coins? Was the experiment successful, and was the change to pure gold and pure silver under Croesus the result of a technological breakthrough, or the natural outcome of a failed experiment? Was the first money a swindle, as Bolin (1958) famously asserted? Did the coins circulate above their intrinsic content, and if so, by what mechanism?

## 4.3 *Existing theories*

Historians and numismatists have long pondered these questions. The variability of the intrinsic content had been noted in the late 19th century through specific gravity measurements, and has been confirmed (if not the estimated proportions) by modern analysis.

There are three broad categories of explanations for the characteristics of the first coinage.

The first category can be called "commercial": going back to the intuitions of Aristotle (*Politics* 1257a, 4th c. BC) and Paulus (*Digest* 18.1.1, 2nd c. AD), it relies on the use of money to solve the double coincidence of wants problem, without (Aristotle) or with (Paulus) State intervention. In a common version, coinage would have had a private origin, and its purpose was to facilitate commercial transactions (Babelon 1894).

But it has been argued that the coins could not have been designed for retail trade: they are too large, and traders in local market would not have produced such an innovation; individuals would have gotten no advantage from issuing them because it is unlikely the coins would have returned to them (Cook 1958, 260). Long-distance trade per se was unlikely to have created a need for coins: such trade had taken place for millennia without coinage, and no early coinage, it is argued, circulated far from its place of issue; first coins to circulate widely were from Thrace and Macedonia, then Athens, all rich in silver (Kraay 1964). Moreover, Mesopotamia seemed to feel no need for this solution for many centuries before, and several centuries after, the emergence of coinage.

A second category of explanations sees money as solving an accounting or payments problem. In this view, coins were invented by the State to facilitate its accounts and make large and regular payments, for example to mercenaries (Cook 1958) or as legal tender for payment to and by the State (Kraay 1976), or as gifts (Price 1983). But it has been noted the Babylonian and Assyrian empires surely had the same needs. Furthermore, why would the recipients accept electrum coins as payments, if they weren't useful for them? Finally, the absence of clipping seems to show that the coins were weighed, and therefore standardization of weights per se added nothing to the content of the coins.

The third broad category of explanations can be called fiscal theories. Note that theories of the past 50 years have focused on the Lydian coinage, and have tended to minimize or ignore the multiplicity of coins types and possible issuers.

Bolin (1958) started from the highly variable content of coins, believed that parting technology was available so that variation in content did not merely reflect the raw material (which he thought roughly constant), but was the result of deliberate action. He further assumed that content could not be detected by the public without difficulty, and that coins circulated as if they were made of natural alloy (70% gold). It follows that diluting the content allowed the State to make a profit; the precision in weights was only hiding the variability in fineness. In his words, the birth of money was a "large-scale swindle."

The notion that electrum coins circulated at a value far above their intrinsic content receives wide support. Kraay (1976) and Price (1989) found support for this view in the circumstances under which Croesus issued pure gold and silver coinage. Croesus first issued gold staters at 10.9g and silver staters at 8.06g. Not long after, the gold stater issues were replaced by a "light" gold stater at the same weight as the silver stater, a system that was essentially maintained after the Persian conquest. They hypothesize that the first gold coins were issued at 10.9g to exchange 1 for 1 with the 14g electrum staters:

that is, the electrum staters were valued as if they contained 78% gold (neglecting the value of the silver).

A variant of the fiscal theory has emerged in recent years, hinging on the role of the State as guarantor of the value of coins. Holloway (1978) noted that natural electrum was in fact highly variable and hard to assay: this made it unsuited as numeraire (like silver in Mesopotamia). By stamping coins, the issuer provided a fixed value, and allowed itself some profit. But how was the value fixed? Wallace (1987) provided a mechanism for this fixation of value. He started from the following premises: (1) coins made of electrum, (2) had regularized weights, (3) were stamped. He wanted a theory that explained both supply of coinage (profit to the issuer) and demand for coinage (acceptability for the recipient). He rejected the notion that the parting technology was available, and assumed that assaying was difficult (as suggested by the variability of the coins themselves). The first premise was an obstacle to turning electrum into money. Furthermore, given that coins were weighed in transactions, the second premise added nothing, but implied that coins of same weight were intended to have the same value. Only the third premise remains operative: since the stamp could not guarantee content (which was variable), it must have guaranteed value by being a promise of redeemability. In his view, the multiplicity of types does not imply that there were private issuers.

Robert Wallace's theory has proved extremely influential, and has been debated and refined, including by himself. In a later contribution, Wallace (2001, 130) proposed that electrum was issued originally at 75% fineness, and progressively debased: "they gradually lost their value in the marketplace" (which seems to contradict the theory that their value was pegged by a promise of redeemability).

Le Rider (2001) rejected Wallace's premise that parting was unavailable and assaying difficult. Instead, he saw Lydia as a closed monetary system, in which the State imposed overvalued coinage for profit: coins at 55% gold circulated as if they were 70% gold. Why did the State stop issuing such profitable coins? He believed that the change to pure gold and pure silver coinage happened after Persian conquest, as a result of political changes. That belief has now been disproved by archaeological evidence (Cahill and Kroll 2005).

In the view of Kroll (2001b), electrum coinage was a failed experiment, quickly replaced by gold and silver coinage. Kroll (2008) broadly accepts the Wallace story, shorn of the "redeemability" aspect: the stamp somehow magically establishes the overvaluation of the coinage. He presents the following story: electrum was abundant in Lydia, but being of variable proportions and easily diluted, was "poorly suited for monetary exchange." He nevertheless postulates "a preceding period of uncertain

duration” during which electrum bullion was used for exchange, until coinage solved the problem. How did it do so? By “transferring its valuation from physically weighing and assaying to the authority of the issuer, who was identified by the authenticating stamp.” This proved to be “remarkably profitable,” because it is assumed that Lydian coins of electrum diluted to 55% gold were valued as if they were undiluted, at 72%.

## 5 Conclusion

The existing theories seem to me unconvincing. The most current theory relies essentially on a state-based model of coin issue: the state was able to issue overvalued coinage and profit from the difference between market value of the intrinsic content and the circulation value of the coins. But the theory does not account for the possibility of competition among issuers, nor does it spell out what the market value of the intrinsic content might be. It is easy to come up with reasons for an issuer to want to circulate overvalued coins, but it seems harder to account for the demand for such coins. Assumptions about the available technology for distinguishing fineness and for separating gold and silver seem crucial, but no consensus has emerged on these questions, nor are the assumptions clearly laid out and their consequences fully taken into account. Monetary economists should be able to help!

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