And now for something completely different...
On the Origin of Specie

François R. Velde

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coinage (canonical form of money) has been with us for 2600+ years
how did it get started?
  it turns out that the circumstances are a little surprising . . .
my attempt at stylizing the facts:
Motivation

- coinage (canonical form of money) has been with us for 2600+ years
- how did it get started?
  - it turns out that the circumstances are a little surprising...
- my attempt at stylizing the facts:
  - multiple issuers
  - full range of denominations, precisely weighed
  - intrinsic content appears random and “information-sensitive”
  - no good theory, but the facts are still changing...
1. Introduction

2. Historical evidence

3. Physical evidence

4. Facts and theories

5. Conclusion
The Context
Historical evidence

The context
The Lydians

- geography
  - inland region of Western Turkey centered on Sardis, at foot of Mount Tmolos, river Pactolus flowed through the city

- history
  - Lydians had been living in the area around Sardis since at least 12th century BC
  - language related to Hittite, Luwian (Anatolian languages)
  - dynasty change: Gyges (680–644 BC) πολύχρυσος, attested in Assyrian sources as “Gugu”
  - he and his successors (the Mermnads) fight with Greek cities repeatedly
  - Alyattes (610–560 BC) and Croesus (560–546 BC)
  - destruction of the Lydian Empire by the Persians in 546 BC
Historical evidence

The Lydians (2)

- **economy**
  - rich agriculture (wheat, barley, olives, figs, nuts, wine)
  - skilled in weaving (legend of Arachne)
  - population of Sardis estimated at 20,000+

- **money**
  - King Midas (of neighboring Phrygia) washed away his accursed gift in the Pactolus
  - Herodotus (1.94.1): the Lydians were the first retailers (πρῶτοι κἀπηλοί)
  - Herodotus (ibid.): “the first men whom we know who coined and used coins of gold and silver”
  - Xenophanes of Colophon, c570–c475 BC, cited in a 1st c. AD dictionary: the Lydians were the first to strike coins (but other theories existed)

- that’s it for the historical sources!
Birthplace of coinage
Historical evidence

Before coins

- Gold used in jewelry since 5th millennium BC, silver since 4th millennium BC
- Egyptian did not use coins until Alexander the Great (4th c. BC)
- Mesopotamia: silver used as unit of account to express prices almost exclusively after c1500 BC
- Prices always expressed as “1 shekel is equivalent to X units of . . .”
- Silver hoards (10th-8th c. BC) found in Middle East, chunks of silver of random weights (*Hacksilber*)
- Gold-silver ratio: 8–10 to 1
The first coins

- What is a coin?
  - medium of exchange
  - lumps of metal whose observable characteristics make them interchangeable
The first coins

- What is a coin?
  - medium of exchange
  - lumps of metal whose observable characteristics make them interchangeable

This is not a coin.
The first coins

- What is a coin?
  - medium of exchange
  - lumps of metal whose observable characteristics make them interchangeable

This is a coin.
The first coins = collection of objects that share certain characteristics

- Context: Western Turkey (Asia Minor), 7th–6th century BC
- Weight: weights appear to be normalized
- Physical appearance: obverse and reverse
- Content: made of a mixture of gold and silver
Historical evidence

The first coins

Location of finds
Historical evidence

Dating

- in general, dating ancient coins relies on
  - archaeological finds to provide absolute anchor points for the chronology
  - designs: stylistic correspondences with dated objects (jewelry, pots, sculptures)
  - designs: stylistic evolution to which some speed is assigned
  - dies: large number of dies for a given series suggests large quantities and/or long time period
- electrum coins:
  - very few coins have been found in archaeological contexts
  - most famous “hoard”: the Artemision in Ephesos, a major cult center of the goddess Artemis
  - several successive early temples, one destroyed by a flood; “Croesus temple” built c560 BC (controversial)
  - in the basis of the sanctuary, large number of electrum coins found in 1904–05
  - “hoard” very rich (dozens of types, including plain) but difficult to interpret
    - original theory: foundation deposit placed at one time
    - most recent theory: remains of past sacrifices (over a potentially long period of time) swept into the foundation of the reconstructed sanctuary
  - more recent finds near the temple are dated to 630–615 BC: terminus ante quem but no terminus post quem
- numismatists tend to think that the electrum coins were produced during a relatively short span of time (a few generations)
Historical evidence

Dating
Physical evidence

- Coin weights and standards

**Coin weights**

![Bar graph showing coin weights on a logarithmic scale.](image)
Physical evidence

Coin weights and standards

Coin weights

![Coin weight distribution graph](chart.png)

- The graph displays the distribution of coin weights relative to 14.67g on a log scale.
- The x-axis represents the weight relative to 14.67g, ranging from 1 to 200.
- The y-axis represents the count of coin weights.
- Peaks indicate clusters of similar weights.
Physical evidence

- Coin weights and standards

Coin weights

weight relative to 14.67g and 17g (log scale)

<table>
<thead>
<tr>
<th>count</th>
<th>192</th>
<th>96</th>
<th>48</th>
<th>24</th>
<th>12</th>
<th>6</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
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<tbody>
<tr>
<td></td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>120</td>
<td>140</td>
<td>160</td>
<td>180</td>
<td>200</td>
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</table>
Physical evidence

- Coin weights and standards

## Coin weights (Milesian standard)

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

Coin weights and standards

Precision

Kernel estimate of weight density

log-weight relative to the denomination
Weights

- coins cluster by weight
- clusters can be collected into two (or three) weight standards
- call each cluster a denomination
- for each standard, an extended suite of denominations spanning two orders of magnitude, based on powers of 2
  - contrast with medieval evolution (Redish-Weber)
- for each denomination, the range of observed weight is very narrow (1% STD for the trites)
- slight difference between Milesian and others: no halves in the Milesian, no thirds in the others
Physical Appearance

- **Obverse**
  - either smooth, striated, or design (geometric, floral, animal, mythological)

- **Reverse**
  - set of (mostly) square punches (there are exceptions)
  - the pattern or punches matches well with the weight standards
## Standards and reverse punches

<table>
<thead>
<tr>
<th>standard</th>
<th>weight</th>
<th>1</th>
<th>1/2</th>
<th>1/3</th>
<th>1/6</th>
<th>1/12</th>
<th>1/48</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lydo-) Milesian</td>
<td>14.0–14.3</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phocaian</td>
<td>16.2–16.5</td>
<td>■</td>
<td></td>
<td></td>
<td>■</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samian (Euboic)</td>
<td>17.0–17.5</td>
<td>■</td>
<td>■</td>
<td></td>
<td>■</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A full house (the Phanes series)

stater, 14.01g (British Museum): ΦΑ.ΝΟΣ ΕΜΙ ΣΕΜΑ
Physical evidence

- Coin types

A full house (the Phanes series)

![Image of a coin]

trite (1/3), 4.72g: ΦΑΝΕΟΣ
A full house (the Phanes series)

hekte (1/6), 2.35g
A full house (the Phanes series)

hemihekte (1/12), 1.17g
A full house (the Phanes series)

myshemihekte (1/24), 0.59g
A full house (the Phanes series)

1/48, 0.29g
A full house (the Phanes series)

1/96, 0.14g
The Samian standard

stater, 17.32g (Paris)
The Samian standard

hemi-stater (1/2), 8.76g (Paris)
The Samian standard

hekte (1/6), 2.86g (Boston)
The Samian standard

hemihekte (1/12), 1.39g (British Museum)
Series

- observed weights and reverse punches allow to sort into three standards
- obverse designs allow to sort into series
- there are many series (up to 100) and very few can be traced to a specific location
<table>
<thead>
<tr>
<th>Weidauer</th>
<th>Denominations represented</th>
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</thead>
<tbody>
<tr>
<td>Münzstätte</td>
<td>1/2</td>
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<tr>
<td>Sardes</td>
<td></td>
</tr>
<tr>
<td>XV</td>
<td>Löwenkopf m. 4-strahliger Warze</td>
</tr>
<tr>
<td>Kar I.4</td>
<td>Löwenpranke</td>
</tr>
<tr>
<td>XVI</td>
<td>Löwenkopf m. mehrstrahliger Warze</td>
</tr>
<tr>
<td>Kar I.6</td>
<td>Löwenpranke</td>
</tr>
<tr>
<td>XVilb</td>
<td>Valvel</td>
</tr>
<tr>
<td>XVllc</td>
<td>Valvel</td>
</tr>
<tr>
<td>XVllId</td>
<td>Valvel</td>
</tr>
<tr>
<td>XVlll</td>
<td>kalil</td>
</tr>
<tr>
<td>XI</td>
<td>Eberköpfe</td>
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<tr>
<td>XIV</td>
<td>Löwenproteome</td>
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<tr>
<td>Milet</td>
<td>XX</td>
</tr>
<tr>
<td>XXI</td>
<td>Stossender Tier</td>
</tr>
<tr>
<td>XXIV</td>
<td>Liegendes Pferd</td>
</tr>
<tr>
<td>Ephesos</td>
<td>V</td>
</tr>
<tr>
<td>VI</td>
<td>Eingerahmte Biene</td>
</tr>
<tr>
<td>VII</td>
<td>Hirschproteome</td>
</tr>
<tr>
<td>VIII</td>
<td>Phanes</td>
</tr>
<tr>
<td>IX</td>
<td>Gorgoneia</td>
</tr>
<tr>
<td>unbestimmt</td>
<td>XIX</td>
</tr>
<tr>
<td>XXVI</td>
<td>Pferdekopf</td>
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<td>XXVII</td>
<td>Pegasosproteome</td>
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<tr>
<td>unbestimmt</td>
<td>XXXIII</td>
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<tr>
<td>XXXVI</td>
<td>Löwenkopf und Skorpion</td>
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<td>XXXIV</td>
<td>Löwentatze und Skorpion</td>
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<tr>
<td>XXXV</td>
<td>Löwentatze und Löwenkopf</td>
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<tr>
<td>I</td>
<td>Typenlos</td>
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<td>II</td>
<td>Geriefelt</td>
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<td>III</td>
<td>Ziegenproteome</td>
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<td>IV</td>
<td>2 Hähne</td>
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<td>X</td>
<td>Widderköpfe</td>
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<td>XI</td>
<td>Widderproteome</td>
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<tr>
<td>XII</td>
<td>Kniender Widder</td>
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<td>XII</td>
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<td>XXIII</td>
<td>Weibliches Raubtier</td>
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<td>XXV</td>
<td>Pferdeproteome</td>
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<td>XXVIII</td>
<td>Schreitender Pegasos</td>
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<td>XXIX</td>
<td>Swastika im Quadrat</td>
</tr>
<tr>
<td>Series and denominations</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td></td>
</tr>
<tr>
<td>Physical evidence</td>
<td></td>
</tr>
<tr>
<td>— Coin types</td>
<td></td>
</tr>
</tbody>
</table>

| XXX  | Kreuzornament im Quadrat | x |
| XXXI | Löwenkopf von vorn im Quadrat | x x x |
| XXXII| Löwenkopf von vorn | x x x o x |
| XXXVII| Bärtiger Kopf | x |
| XXXVIII| Menschlicher Kopf von vorn | x o |
| XXXIX | Orientalisierender Kopf | x x |
| XL   | Geflügelter Dämon | o x x x |
| XLI  | Geflügelter androcephaler Stier | x |
| XLIa | Delphin | o o o x x |
| XLIc | Stierkopf von vorn | o x x |
| XLIId | star + polygon | o o o o o |
| XLIe | lion + male bust | o o o o o |
| XLII | Greifenprotome | x |
| XLIIa | Greifenkopf (Phokaia) | o o o o o o x |
| XLIIb | Greifen (geflügelter) | o o o x x |
| XLIII | Phokäischer | x |
| XLIV | Löwenkopf auf Scheibe | x |
| XLV  | Delphine | x |
| XLVI | Robbe (Phokaia) | x o o o o o |
| XLVIa | Robbenkopf (Phokaia) | o o o o o o x |
| XLVII | Menschliche Büste | x x |
| XLVIII | Menschlicher Kopf | x x |
| XLVIIIa | Gorgoneia | o |
| XLVIIIb | Krabbe | o o o |
| XLVIIIc | Fibula | o o o o |
| XLVIIIId | Skorpion | o o o o |
| XLVIIIle | raised swastika | o o |
| Samisch-euböischer     |
| L    | Adler | o |
| Lb   | Eagle head | o o o |
| Lc   | plain 1 | o |
| Ld   | plain 2 | o |
| Le   | plain 3 (whirlpunch) | o |
| LF   | 3-sided square | o |
| Lg   | duck | o |
| XLLa | Käfer (geflügelter) | o o |
| "Leichter samischer" |
| LI   | Gekerbt | x x |
Identifying a few types
Physical evidence

Coin types

Identifying a few types

ΜΙΛΗΣΙΩΝ = Miletos, 2nd c. BC
Identifying a few types
Identifying a few types

ΕΦ[ΕΣΟΣ] = Ephesos, 4th c. BC
The Lydian or “royal” series

▶ one group of series has been attributed to Lydia (cf. historical sources)
▶ it belongs to the Milesian standard
▶ one series features a lion head in profile with distinctive “wart” or “globule”
▶ some of the coins have an inscription: ΦΑΛΦΕΤΑΛΙΜ = “[I am] of Walwetas” (Alyattes?)
▶ another die-linked series bears: ΚΫΚΑΛΙΜ or ΚΡΚΑΛΙΜ = “[I am] of Kukas/Krkas” (Gyges? Croesos?)
▶ another boar-head series (die-linked) has ΛΑΤΕ or ΦΕΤΑ or Τ῞Ε (???)
▶ smaller denominations: the “lion’s paw” series
▶ no stater ever found
The Lydian series
The Lydian series
The Lydian series
The Lydian series

my coin!
The Lydian series
The Lydian series
Physical evidence

- Coin types
Physical evidence

Coin types

Series and weights

![Graph showing series and weights](image-url)
Series and weights

![Graph showing weight relative to 14.67g (log scale)]
Physical evidence

- Coin types

Series and weights

![Graph showing the distribution of plain and striated coins by series and weight. The x-axis represents the weight in units, from 96 to 1, and the y-axis represents the frequency, from 0 to 20. The graph displays the peaks corresponding to different series and weights.](image-url)
Gold and Silver in Mesopotamia

- gold was a commodity (except for the Kassite period, middle of 2nd millennium BC)
- silver was the numeraire
- gold assumed to have come from Egypt/Nubia
- silver came from the Taurus mountains, Iran, the Aegean
- evidence on the assaying of gold (18th c. BC), different grades of gold ("shiny", "red" twice as valuable, 15th c. BC)
- quality of silver indicated in Assyrian sources from 700 BC
  - standard was 87.5%
  - other grades: 91.7% (between 605 and 579 BC), 83.3% (599 BC), 80% as the silver used in trade (572–562 BC)
- technology for assaying?
  - 18th c. BC touchstone found in Sumeria
  - Greek sources: Theognis (6th c. BC): βάσανος, Bacchylides (5th c. BC): Λυδία λίθος
  - Theophrastus (early 3d c. BC) claims precision of 1/288
  - defeated by ternary alloy (copper)
Mixing and Separating Gold and Silver

- separating gold/silver from base metals (Cu, Pb) is easy
- *cupellation* process known since 4th millennium
- separating gold from silver is different
- evidence for burnishing gold/silver alloys to obtain a surface richer in gold (Babylonia)
- *cementation* process:
  - gold is hammered in thin strips, mixed with salts and brick powder
  - heated between 500°C and 800°C (below melting point), silver forms silver chloride gas, absorbed in brick and clay vessel
  - silver can be extracted by cupellation from brick and ground clay
  - First archaeological evidence for cementation in 575–550 BC Sardis
  - Lydian coinage after 560 BC is pure (98–99%) gold and silver
  - no clear-cut evidence for systematic use of pure gold before (New Dynasty Egypt had close to pure gold, could be from better sources)
Physical evidence

- The coins’ metal content
- The technology for recognizing and separating metals

Electrum

- ἥλεκτρον (amber for Homer and Hesiod, metal for Sophocles): alloy of gold and silver
- Natural gold (placer or reef) naturally contains a variable quantity of silver (+ a little copper, PGE inclusions for placer gold)
- Herodotus (1.50) tells of a gift by Croesus to Delphi of
  - ingots of (ἀπεφθος χρυσός = “boiled gold”) weighing 2.5 talents each,
  - ingots of alloy (λευκὸς χρυσός = “white gold”) weighing 2 talents each → 70% gold
- Placer gold from Pactolus: 17–24% silver (modern test), two nuggets found in Sardis have 30% and 16% silver
### Metallic content of gold ores

Morrison, Barrandon and Breudot (1987)

#### Data on the Composition of Gold Ores

<table>
<thead>
<tr>
<th>Country and Place</th>
<th>Placement</th>
<th>Au</th>
<th>Ag</th>
<th>Cu</th>
<th>Fe</th>
<th>Other Metals</th>
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<tbody>
<tr>
<td><strong>Placer gold</strong></td>
<td>Africa</td>
<td>nuggets</td>
<td>94.6</td>
<td>5.85</td>
<td></td>
<td>Pt:0.15</td>
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<tr>
<td></td>
<td></td>
<td>nuggets</td>
<td>86.8</td>
<td>11.8</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>powder gold</td>
<td>84.5</td>
<td>15.3</td>
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<tr>
<td></td>
<td>Guinea</td>
<td>nugget from the Ashanti country</td>
<td>90</td>
<td>9.55</td>
<td>traces</td>
<td>traces</td>
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<tr>
<td></td>
<td>Asia</td>
<td>Afghanistan</td>
<td>96.97</td>
<td>3.02</td>
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<tr>
<td></td>
<td></td>
<td>Burma Schusse-Gyeng</td>
<td>92</td>
<td>8</td>
<td>2.9 (Cu + Fe)</td>
<td></td>
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<tr>
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<td></td>
<td>Biver Tayoy</td>
<td>87.9</td>
<td>9.2</td>
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<tr>
<td></td>
<td>India</td>
<td>Jashpur—nugget</td>
<td>94.64</td>
<td>5.15</td>
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<td></td>
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<td>Babkad, Udaipur</td>
<td>91.7</td>
<td>3.6</td>
<td>4.7 (Cu + Fe)</td>
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<td>Wynaud district</td>
<td>91</td>
<td>8.7</td>
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<tr>
<td></td>
<td>Siberia</td>
<td>Boruschka, Nijni-Tagilisk district</td>
<td>83.85</td>
<td>16.15</td>
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<tr>
<td></td>
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<td>Boruschka</td>
<td>91.36</td>
<td>8.35</td>
<td>0.29 (Cu + Fe)</td>
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<tr>
<td></td>
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<td>Boruschka</td>
<td>94.14</td>
<td>5.23</td>
<td>0.39 (Cu + Fe)</td>
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<td>Perroe Pawlovsk, near Beresow</td>
<td>92.6</td>
<td>7.08</td>
<td>0.02</td>
<td>0.03</td>
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<td></td>
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<td>Alexander Andrejewsk, near Miosk</td>
<td>87.4</td>
<td>12.97</td>
<td>0.09</td>
<td></td>
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<tr>
<td></td>
<td>Europe</td>
<td>Great Britain</td>
<td>Biver Mowddach, Wales</td>
<td>84.9</td>
<td>14.7</td>
<td>0.34</td>
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<td></td>
<td></td>
<td>Kildonan Burn, Sutherland, Scotland</td>
<td>81.1</td>
<td>18.4</td>
<td>SiO2: 0.4</td>
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<tr>
<td></td>
<td></td>
<td>Italy Po valley</td>
<td>92</td>
<td>4.5</td>
<td>3.5</td>
<td></td>
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<tr>
<td><strong>Reef gold</strong></td>
<td>Asia</td>
<td>Wynaud district</td>
<td>86.9</td>
<td>11</td>
<td>2.1</td>
<td></td>
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<tr>
<td></td>
<td>Siberia</td>
<td>Kiel</td>
<td>87.4</td>
<td>12.6</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Berezow</td>
<td>91.9</td>
<td>8</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Berezow</td>
<td>93.8</td>
<td>5.9</td>
<td>0.08</td>
<td>0.04</td>
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<td>Fuses</td>
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<td>14.7</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Europe</td>
<td>Bohemia</td>
<td>Emle</td>
<td>91.3</td>
<td>8.4</td>
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<td></td>
<td>Transylvania</td>
<td>Verespotok</td>
<td>60.5</td>
<td>38.75</td>
<td>0.75</td>
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<td></td>
<td></td>
<td>Fuses</td>
<td>84.9</td>
<td>14.7</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Ural</td>
<td></td>
<td>70.9</td>
<td>28.8</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>
Methods of Analysis

- destructive (rarely an option)
- non-destructive
  - specific gravity (SG)
    - Archimedes: έυρηκα!
    - good in principle for binary alloys
      \[ x = \frac{SG_{Au}}{SG_{Ag}} - \frac{SG_{Au}}{SG} \]
      
      with \( \frac{SG_{Au}}{SG_{Ag}} = 1.838 \) (Herodotus example: 73%)
    - not good for ternary alloys (copper), or when there are bubbles
    - has been shown to be misleading in practice
  - X-ray fluorescence (XRF)
    - bounce high-energy rays on surface, atoms lose electron, emits radiation
    - available since 1950s
    - relatively cheap, portable
    - only analyzes the surface (problem of surface enrichment)
- proton activation analysis (PAA)
  - make the coin radioactive and measure the decay
  - analyzes the whole coin
  - more costly, not portable
The Samos Hoards

- IGCH 1158
  - found in 1894 on the island of Samos; estimated to be 575–560 BC
  - most of the coins acquired by the Louvre and the British Museum
  - Paris coins analyzed by Nicolet-Pierre and Barrandon (1997)
  - over 60 electrum coins, in a variety of types and denominations (rough surface, lion’s head facing, eagle, flying eagle, flower or wheel, ram looking back)
  - all coins appear to be on the Samian standard

- CH IX.341
  - found c1998, probably on the mainland facing Samos
  - coins dispersed in trade
  - over 45 electrum coins, variety of types and denominations (rough surface, lion’s head facing, flying eagle, duck, square and radiating lines)
  - all coins appear to be on the Samian standard
  - analyzed by Konuk (2005)
The Samos hoards (PAA analysis)
The Samos hoards (PAA analysis)
The Samos hoards (PAA analysis)

- lion’s head facing
- uncertain
- eagle
- flying eagle
- flower or wheel
- wheel
- lion’s head facing with laurel wreath
- ram looking back
- uncertain (GC IX.341)

weight relative to 17.5g, Samos hoards (IGCH 1158, GC IX.341)

% gold

Physical evidence
- The coins’ metal content
- Analysis of the early electrum coinage
The Samos hoards (PAA analysis)

![Graph showing the analysis of the Samos hoards (PAA analysis)]
The Samos hoards (PAA analysis)
Physical evidence

The coins’ metal content

Analysis of the early electrum coinage

XRF analysis of “royals”
Physical evidence
- The coins’ metal content
- Analysis of the early electrum coinage

XRF analysis of “royals”

The graph shows the XRF analysis of “royals” with data points representing different types of coins. The x-axis represents the percentage of silver (% Ag), and the y-axis represents the percentage of copper (% Cu). The data points are categorized into 'royals', 'Samos', and 'other'.
Physical evidence

- The coins’ metal content
- Analysis of the early electrum coinage

SG versus XRF

Graph showing the comparison of % Au measured by SG and % Au measured by XRF.
The coins’ metal content

Analysis of the early electrum coinage

The Falghera collection (XRF analysis)

- other
- Milesian
- Lydian
The coins’ metal content
Analysis of the early electrum coinage

The Falghera collection (XRF analysis)
More recent results

- 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 ± 2%
Evidence on circulation

- again, paucity of archaeological evidence
- hoard evidence: many different types circulated at the same time
- some hoards contain coins of different standards
- some hoards contain only Lydian coins
- absence of wear and clipping noted on the coins (worn appearance due to wear of the dies)
- intriguing presence of bankers’ marks, mostly on “royals” (1/3 and 1/12) but also on plain types
  - could be periodic restampings to maintain legal acceptance?
Bankers’ marks
Bankers’ marks
Physical evidence

— Wear on electrum coins

Shifting modes

![Graph showing the relationship between log-denomination (as fraction of stater) and log-distance between theoretical and actual mode. The graph includes data points represented by stars and a red line indicating a linear trend.]
Physical evidence

Wear on electrum coins

19th c. data

![Graph showing annual weight loss (ppm) vs. log of denomination (F)]
### Price data in Mesopotamia (7th–6th c. BC), Rome (301 AD), and Florence (14th c. AD)

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


The rest is history...

- new gold/silver coinage appears with lion and bull (“Croeseids”)
  - Phase IA: naturalistic animals
    - gold: heavy stater (10.7g), fractions of 1/3, 1/6, 1/12
    - silver: stater (10.7g), fractions of 1/3, 1/6, 1/12, 1/24
  - Phase IB: naturalistic animals
    - gold: light stater (8.06g), fractions of 1/3, 1/6, 1/12
    - silver: stater (10.7g), fractions of 1/2, 1/3, 1/6, 1/12, 1/24
  - Phase II: stylized animals
    - gold: light stater (8.06g)
    - silver: half-stater (5.35g)
  - dating: three coins (heavy gold 1/12, silver 1/12 and 1/24) discovered in rubble of the destruction of Sardis (546BC)
  - Phase IA must date from reign of Croesus
  - Phase IB could be Persian, Phase II generally thought to be Persian

- gold/silver coinage of Darius (522 BC) with slightly modified weights, mainly produced in Western Asia Minor

- gold/silver ratio (assume 1 gold stater = 20 silver half-staters) of 13 1/3, attested in sources
Physical evidence

What happened after the first coins?

A Croeseid
Greek coinage

- Mainland Greece:
  - began coining silver ca 560 BC (Euboea, Athens, Aegina) on a different standard (either 17.4g like Samos, or 12.4g in Aegina)
  - vast expansion of coinage (100 cities mint coins by the 5th c.)
  - bronze coinage introduced in the 4th c.
  - gold coinage in Hellenistic period
  - debasements rare
    - again, contrast with medieval experience
- Asia Minor:
  - mintage of electrum during Ionian revolt against Persia (494–490 BC)
  - a few cities mint silver coins in 6th c. (Erythrae, Ephesus, Miletus, Teos, Colophon)
  - a few cities (Phocaia, Mytilene, Cyzicus) continue electrum (50–55% gold) until Alexander the Great
- East of Lydia: no coinage until Alexander the Great
What happened after the first coins?

1. coinage schmoinage

The Phoenicians, the Carthaginians, and the Egyptians continued to run their economies against their trade without coins. It has generally been thought that there was a lag of centuries between the Greek adoption of coinage and its spread to the Near East. To my knowledge, it has not hitherto been noticed that numismatic scholarship of the last few decades has closed this gap.

It now appears that there was no massive circulation of Greek coinage in the Near East until the Aeginetan turtles, which were soon supplanted by the Athenian owls. At first, the coins arriving from Greece presumably sufficed for their main purpose, which was to be traded back to Greeks for other commodities; but when the volume of Athenian coinage dwindled in the 470s and 460s, their Levantine trading partners filled the vacuum. The relative paucity of Near Eastern coinage and its failure to spread inland (or two or three more generations) show that the barbarians struck coins for the Greek trade, not because they had come to think, as Greeks did, that silver that was not coined was not really money. The earliest Phoenician coins were minted slightly before the middle of the fifth century.

Not only did these peoples not mint coins of their own; at first, they did not even treat the Greek coins as anything more than lumps of silver, to be cut up like anything else if necessary to even up a balance (fig. 9), a practice that they continued in the fifth and even the fourth centuries. They may have recognized that this silver was of reliably good quality; the Babylonians, who were not yet minting coins, refer to them often, distinguishing them from mere Hacksilber, though the latter remained their dominant commercial money.

For this phenomenon, see Starr, Athenian Coinage, 81-84.

In the fourth century, but not before, Tyrian and Sidonian coins were exported widely; Elayi and Elayi (386) attribute this to a decrease in the production of Attic coins, whose place was filled by Phoenician coins.

At Byblos, according to Elayi and Elayi (386); Betlyon is now out of date. Tyre, Sidon, and Arwad began to coin soon afterward: Elayi and Elayi 89-90, 240-41, 363-65.

Meshorer, 1:13-18. Loewe (147-50) claims that the expression!eror naqub in Haggai 1:6 implies that coins were in common use in Judaea as early as 520 B.C.E., but he admits that the term might also apply to a bundle of Hacksilber and that coins themselves in that period in the Near East were still treated as Hacksilber (cf. Kraay, “Hoards,” 84).


On the transition from the use of uncoined silver to the use of coins in Babylon see Vargyas, “Kaspu girmu,” “Silver and Money,” and Vargyas, History of Babylonian Prices, 24-34, 42-44, 46-51, cf. 21 n. 116, and Le Rider, 30-35.

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Fig. 9. The Jordan hoard: whole coins, chopped fragments of coins, and fragments of silver. (Photo courtesy of the Ashmolean Museum, Oxford.)

Defeated Croesus, seem to have used them chiefly, if not exclusively, in the vicinity of the old Lydian empire. The Carthaginians, who did not mint coins until the end of the fifth century, began the practice on Sicily, where they were in constant contact with Greek colonists who had been minting coins for generations; they may have needed the coins to pay mercenaries.

The Etruscans, also a commercially active people, were yet later.

Among the Greeks, however, even those who did not mint their own coins—on Crete, for example, coins seem not to have been minted before the fifth century and were widely produced only from the end of the fourth century—apparently used the coins of other states, speaking of them in monetary terms, from the time that they came into general use.

Challenged by Vargyas, “Kaspu girmu,” 249-60.

Ameling, Karthago, 188-89; Jenkins and Lewis, 18.

Howgego, Ancient History, 2.

Stefanakis, 257-60.


Schlumberger; Carradice, “Regal’ Coinage,” 89-90. This view, however, has now been challenged by Vargyas, “Kaspu girmu,” 249-60.

106 Invention of Coinage and Monetization of Ancient Greece

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Hoard from Jordan, c450 BC
Facts and theories

- A summary of the facts
- numeraire and money

Summing up the facts (1)

- preferences
  - gold and silver were durable commodities yielding utility
  - fineness of gold and silver mattered

- technology
  - fineness of gold and silver was detectable, though not easily
  - gold and silver easy to separate from other metals; easy to mix with each other, hard to separate from each other
  - parting not firmly attested before 575BC: may or may not have existed

- endowments
  - Mesopotamia not endowed with either, acquired it by trade in plentiful quantities
  - Lydia endowed with large amounts of natural alloy (electrum) of uncertain fineness

- markets
  - long-distance trade existed for millennia
  - Lydians produced desirable goods and services that were exported (mercenaries to Egypt in 7th c. BC)
  - Ionian cities were active traders
Summing up the facts (2)

- **numeraire and money**
  - silver was in use as unit of account for millennia, ad-hoc medium of exchange for centuries
  - electrum (gold-silver) coins are the earliest coins
  - they come from Lydia and Ionia, starts sometime before 630BC, ends c550BC (except for a few cities)
  - produced in a broad range of denominations (from 1 to 1/96 or even 1/192)
  - many different designs/issuers, each with full range of denominations, coexisted (Samos)
  - precise weights contrasts with highly variable gold content
  - range of content exceeds natural variation of electrum, hence silver must have been added

- **prices**
  - purchasing power of largest coin was very large, smallest coin a few days’ wages
Questions

- Who issued these coins?
  - States (Lydia, cities) or private individuals?
- Why were they so useful in Lydia/Ionia and later Greece, not in the East?
- Why would the issuers take such care with the weights and not the fineness?
- Why did they choose to make money out of a random variable instead of silver?
- Was technology a constraint?
What do historians say?

Three broad categories of explanations for the birth of coinage (Le Rider, 2001)

1. commercial
   ▶ back to the intuitions of Aristotle (*Politics* 1257a, 4th c. BC) and Paulus (*Digest* 18.1.1, 2nd c. AD): solving the double coincidence of wants problem, without (Aristotle) or with (Paulus) State
   ▶ coinage would have had a private origin, its purpose was to facilitate commercial transactions (Babelon, 1894)
   ▶ objections: coins were too large (Cook, 1958), did not circulate outside Lydia/Ionia (Kraay, 1976), Mesopotamia did fine without it for many centuries before (and a few after)

2. accounting/payments
   ▶ coins were invented by the State to facilitate its accounting, make large and regular payments
   ▶ coins were paid out to mercenaries (Cook, 1958), as legal tender for payment to and by the State (Kraay, 1976) or as gifts (Price, 1983)
   ▶ objections:
     ▶ the Babylonian and Assyrian empires had the same needs;
     ▶ why would the recipients accept electrum coins as payments?
     ▶ absence of clipping shows the coins were weighed, hence standardization of weights per se adds nothing

3. fiscal
Fiscal Theories of Money

Note that theories of the past 50 years have focused on the Lydian coinage

- the fraudulent-State theory
  - Bolin (1958) starts from the highly variable content of coins, believes that parting technology was available so that variation does not merely reflect the raw material (which he thought roughly constant)
  - assumes that it could not be detected by the public without difficulty
  - coins circulated as if they were made of natural alloy (70% gold), diluted content allowed the State to make a profit
  - precision in weight hid the variability in fineness
  - the birth of money was a “large-scale swindle”

- objections:
  - raw material was variable in content, not constant
  - parting technology was not available
  - fraud argument assumes that market value of electrum reflected its content
the State as guarantor

- Holloway (1978)
  - 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?

- Wallace (1987) provides a mechanism for this fixation of value
  - (1) coins made of electrum, (2) had regularized weights, (3) were stamped
  - wants a story that explains supply of coinage (profit) and demand for coinage (acceptability)
  - rejects that parting was available, assumes that assaying was difficult (cf. variability of the coins themselves): (1) is an obstacle to turning electrum into money
  - coins were weighed in transactions: (2) adds nothing, but implies that coins of same weight were intended to have the same value
  - only (3) is left: since the stamp could not guarantee content (which was variable), it had to promise redeemability
  - multiplicity of types does not imply private issuers
  - Wallace (2001) twist: coinage began at 75%, progressively debased
Critiques/refinements of the R. Wallace theory

- Le Rider (2001)
  - rejects that parting was unavailable and assaying difficult
  - sees Lydia as a closed monetary system, State imposed overvalued coinage for profit
  - 55% coins circulated as if they were 70%
  - why did it stop? Switch to gold/silver coinage happened after Persian conquest
    - now disproved (Cahill and Kroll, 2005)

- Kroll (2001)
  - electrum was a failed experiment, quickly replaced by gold/silver coinage
  - Kroll (2008) broadly accepts the Wallace story, shorn of the “redeemability” aspect
Discussion

- Recognizability is typically a key characteristic of money (Nosal and Rocheteau 2010)
- Recognizability was not a key characteristic of the first money
- Key puzzle:
  - precise weights vs. random content
  - randomness was not natural
- Existing theories have no problem explaining why a state would want to issue overvalued coinage
- They tend to ignore competition among issuers, coexistence of different designs and standards
- Did technology play a constraining role? (electrum continued for 200 years in some cities)
Conclusion

- None (told you so)
Th-th-th-that’s all folks!