Minted Silver in the Empire of Alexander

Julien Olivier, Frédérique Duyrat, Caroline Carrier, Maryse Blet-Lemarquand

Alexander the Great.
A Linked Open World

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Cover illustration: Reverse of a tetradrachm of Alexander the Great, mint of Damascus (courtesy of the American Numismatic Society, 1947.98.276).

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Minted silver in the Empire of Alexander: old bullion and new

Julien Olivier, Frédérique Duyrat, Caroline Carrier, Maryse Blet-Lemarquand

Introduction

This study follows a previous article published by Duyrat and Olivier in 2010 based on analyses of gold coins from the Seleucid and Ptolemaic Empires[1]. They compared their results with analyses of Macedonian and Eastern coins of several periods including Persian Darics, Macedonian coins in the name of Philip II and Alexander, and Eastern Alexanders. A gold with very low content of platinum (Pt) and palladium (Pd), probably from the Mount Pangeion region, was used by Philip II and by Alexander the Great at the beginning of his reign. Then, a change in the metal composition – the amount of platinum and palladium is much higher – occurred between 328 and 323 BC[2]. This phenomenon can be observed in coins struck throughout the Empire. Duyrat and Olivier concluded that this characterisation of an "Eastern" gold should be explained by the use of the gold of the Persians by Alexander[3]. At the end, these authors showed that the stock of metal coined by Alexander the Great and the *Diadochi* shared common characteristics with the gold of both the Seleucids (Western mints) and the Ptolemies, who probably melted down and restruck the metal taken by Alexander.

In this article, we will focus on silver, the metal more commonly coined in the Greek world. To date, we have three main sources from which to study the origin of the silver used by Alexander to strike his coins: ancient texts, hoards, and die studies.

A recent book by Frank Holt aims to gather all the historical sources concerning Alexander's wealth. On the basis of preceding estimations by François de Callataÿ, he supposes that "there once existed some 24 millions Alexander gold coins and 126 millions Alexander silver coins"; "Alexander and his successor monetized at best only 50 % to 75 % of the bullion taken from Susa and Persepolis"[4].

Coins in the name of Alexander were so numerous that they circulated throughout the Empire. They form the totality or a significant part of hoarding between 330 and 300 in Asia Minor, Cyprus, the Near East, Egypt, Greece, Macedonia and Thrace. This dispersion can be

1 Duyrat & Olivier 2010.
2 Guerra & Gondonneau 2000.
3 The darics struck in Sardis before the conquest of Alexander have the same composition as this "Eastern" gold.
4 Holt 2016, 165-166; Callataÿ 1989.

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associated with the return of veterans to Macedonia, Thrace and Greece as suggested by Margaret Thompson[5], a trend probably reinforced by other phenomena such as the price of silver[6]. According to this data cluster, there is a movement of coined metal from the Near East to Greece and Macedonia. In this context, is the pattern of silver identical to that of the gold? Metal analyses can bring new information to the debate.

To study minted silver, we selected 74 Philip and Alexander silver coins struck between *c.* 330 and *c.* 300 – with the addition of 12 Macedonian coins dated to the 290s and 270s. We have followed Martin Price's dating of the coinage in the name of Alexander the Great and Philip Arrhidaeus[7]. The last third of the 4th century is a turning point in the history of the Eastern Mediterranean. Changes in the stock of metal should be expected after the seizure of Persian treasuries, looting, and the general upheaval caused by the Macedonian conquest. During this period, coins were struck in many different regions of the Empire and of course, it was impossible to analyse a sample of all in the short span of the OPAL project. Our investigations focused on two areas: Macedonia (Pella and Amphipolis) and Phoenicia (Aradus, Byblus, and Sidon). These areas play an important role in Hellenistic history, the

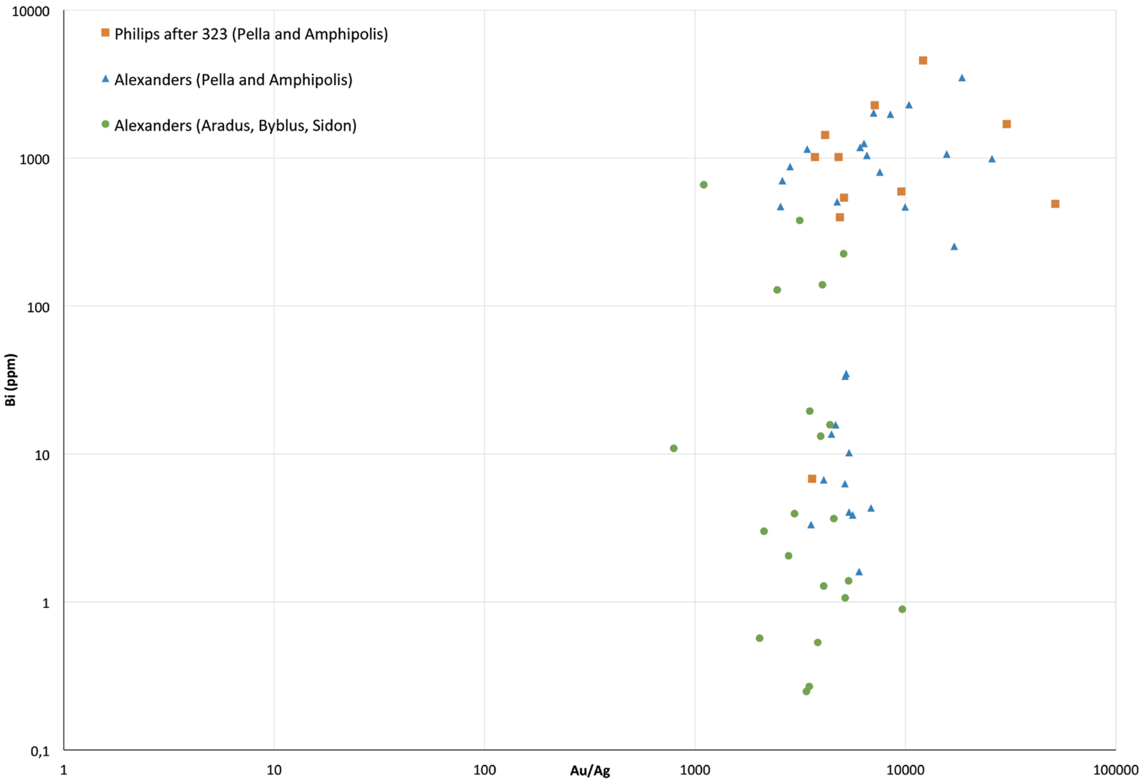

Fig. 1. Bismuth (Bi) against gold to silver (Au/Ag) ratio for coins struck in Macedonia and Phoenicia from c. 330 to c. 270 (logarithmic scale).

5 Thompson 1984.
6 Duyrat 2016, 442-448.
7 Price 1991.

first as the cradle of the dynasty, the second, together with Cyprus, as the base of Persian naval power in the Mediterranean. Both have a coinage before the conquest of Alexander that can be compared with the coins he produced as well as those struck under the *Diadochi*. A small set of Babylonian Alexanders was included: Babylon was a political capital and a very productive mint; its issues travelled to the Mediterranean in large quantities. Some other analyses were conducted in order to supplement these data: in Macedonia, silver coinage of Philip II could be usefully compared with later coins. Furthermore, Alexander continued to issue Philips while he started the production of a short "eagle" series, before the massive issues with his personal types. 19 Macedonian Philips and eagle coins struck before *c.* 330 were also analysed (fig. 1).

Metallurgical analysis of the silver coins using LA-ICP-MS

Laser Ablation Inductively Coupled Plasma Mass Spectrometry was performed to determine the elemental composition of the silver coins[8]. A laser is focused onto the surface of the coin to carry out a micro-sampling, the aerosol of matter obtained from this ablation is sent to a plasma to be dissociated and ionised, then the ions obtained are separated in the sector fields of magnets and finally are detected[9]. LA-ICP-MS presents many advantages for analysing ancient silver-based coins in order to discuss archaeological, numismatic or historical questions. The tiny holes created in the coin cannot be seen without magnification. The contents of a very large number of elements can be determined with detection limits reaching the sub-part per million (or mg/kg) level, which means that silver, copper, and also a whole set of the trace elements that characterises the ancient metals can be studied.

It is well known that the surface of silver coins can have a composition different from that of the interior of the coins[10]. Yet this inner part represents the metal worked in the mint and is of importance for numismatic studies. The coins made of silver-copper alloys are especially likely to present a surface depleted in copper, a property usually known as "silver surface enrichment". These variations in composition between the surface and the interior of coins result from the combination of phenomena occurring during the production of the blanks, the circulation of the coins and their burials.

To overcome this major impediment to the relevant analysis of silver coins the depth profile analysis mode associated with the LA-ICP-MS is used[11]. The progressive penetration of the laser into the coin is coupled with a time-resolved measurement of the signal. Thus

8 The metallurgical analyses were performed at the IRAMAT-CEB (CNRS, univ. Orléans) laboratory using an Element XR (Thermo Fisher) ICP-MS coupled to a Resolution M-50-E (Resonetics) 193 nm excimer laser ablation system.

9 For further information on the LA-ICP-MS method applied on silver alloy coins see Sarah & Gratuze 2016; Sarah *et al.* 2007.

10 The question of the "surface enrichment" of ancient silver-copper alloy coins and the impacts of this phenomenon for the metallurgical analysis have been much discussed. See particularly Ponting 2012; Sarah & Gratuze 2016.

11 Sarah & Gratuze 2016; Sarah *et al.* 2007.

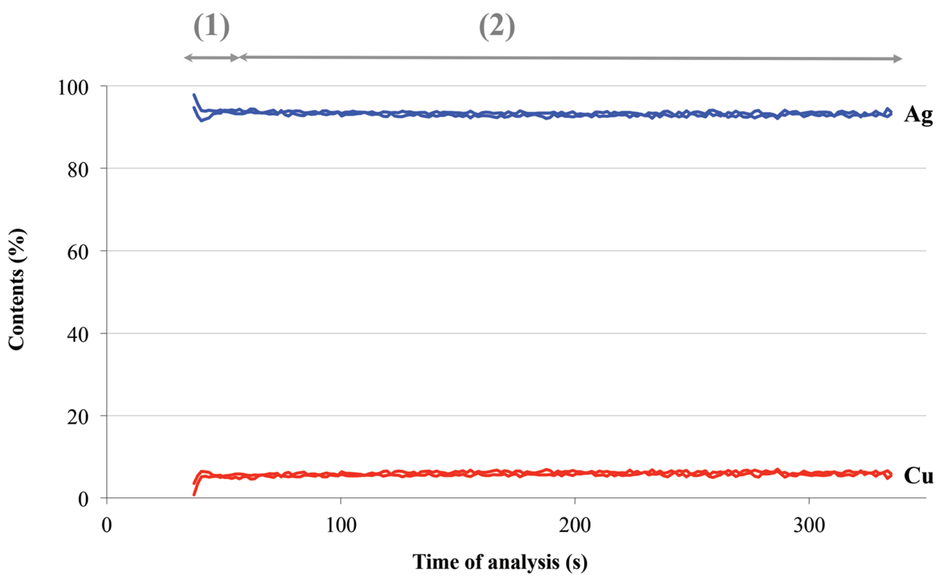

Fig. 2. Example of concentration depth profiles using LA-ICP-MS of silver and copper for the coin BnF MMA Delepierre 3006. (1) "Perturbed" surface layer; (2) "inner part" of the coin. Two micro-samplings were carried out. The laser was triggered at time 30 seconds.

the diagram showing the signal versus the time of analysis reflects the evolution of the composition from the surface to the inner part of the coin.

A concentration depth profile for a fifth of a tetradrachm minted by Amphipolis is shown in fig. 2 for the contents of silver and copper. The signals obtained for the surface of the coin during the first ten seconds show a slight silver enrichment in detriment to copper (part number 1) then the contents stabilise (part number 2) to the real composition of the minted alloy that is roughly 93 % silver and 6 % copper. The depth profile mode is also useful to calculate the reliable contents of the minor elements because the silver coins' surface sometimes appears to be contaminated with certain elements (*e.g.* iron (Fe), zinc (Zn), tin (Sn)).

The silver coins analysed for this study were mainly made of "pure silver" (freshly produced or recycled) because their copper contents are most of the time inferior to 1 % meaning that this latter element was not deliberately added to debased silver. Ancient silver metals also contain other impurities which could not be removed below thresholds that depend on their behaviour during the metallurgical processes, the skill of the metallurgists and the conducting of the reactions. In Antiquity the production of silver usually required the separation of lead from silver, which was achieved by cupellation[12], an oxidising process carried out at around 1000 °C.[13].

12 See Conophagos 1980 for the exploitation of the Laurion mines.
13 See for instance Craddock 2010 for generalities on the ancient metallurgy of silver.

How do the impurities of silver ores behave during this metallurgical operation? What can be deduced from the contents of these impurities found in silver coins? Which trace elements can help to distinguish metals of different origins? Experimentations of cupellation carried out so far do not answer all these questions[14] because little reliable archaeological data on the production of silver in Antiquity is available to us. Some conclusions can be firmly drawn from these experiments. The behaviour of gold and silver during this process being similar, the gold content to silver ratio remains unchanged from the silver ore to the silver metal[15] thus gold is a relevant tracer. Moreover the gold to silver ratio depends on the type of lead-bearing silver ore[16]. Most of the other impurities of silver ores are more or less efficiently separated from silver (arsenic, tin, antimony, etc.)[17]. Cupellation experiments and studies made on archaeological cupellation remains have proved that bismuth can be parted from silver but this parting occurs only at the very end of the process[18]. Consequently the bismuth contents in silver objects depends on its concentration in the silver ore and on the way the cupellation process was carried out. This observation explains why bismuth appears to be an interesting trace element to discriminate between different silver metal stocks[19]. Thus, our choice was to examine the gold to silver concentration ratios (Au/Ag) and the bismuth concentrations in order to study the silver supplies used to mint Alexander's coinages. Both these parameters are displayed in the following graphics and the contents in silver, copper, lead, bismuth and the Au/Ag can be found in the appendix.

Phoenicia

Phoenicia was an interesting area to start this programme of analysis. Analyses of silver issues of the Achaemenid period have previously been performed by the IRAMAT-Centre Ernest Babelon, allowing us to compare the results of the analyses of silver Alexanders in the long term[20]. The tradition of coinage in Phoenicia dates back to the mid-5th century and was not interrupted by the Macedonian conquest. Furthermore, Phoenicia is an interface between the East and the Mediterranean. In her study of Aradus, Duyrat showed that, contrary to what several scholars had suggested, the issues of Alexanders in that city are closely related to the military activity of Alexander and his successors[21]. Therefore, if the general belief that the Achaemenid kings' reserves of gold and silver had been struck by Alexander and his successors was true[22], it is likely that we should see a change in the characterisation of the metal used by the Phoenician mints. The route from the East to the

14 For a recent review of these questions see the quoted references in Blet-Lemarquand *et al.* 2014.

15 Pernicka and Bachmann 1983. It is the same for other elements like platinum or palladium which are difficult to oxidise.

16 Meyers 2003.

17 Pernicka & Bachmann 1983.

18 Pernicka & Bachmann 1983; L'Héritier *et al.* 2015; Flament *et al.* 2017.

19 See, for example, how bismuth contents are used for archaic silver coins in Gale *et al.* 1980 or for Roman silver coins in Butcher & Ponting 2015.

20 Elayi *et al.* 2012a (Byblus); Elayi *et al.* 2012b (Arwad).

21 Duyrat 2005a, 214-217.

22 Holt 2016, 165-166; Callataÿ 1989.

Mint	Activity	Price 1991
Aradus	*c.* 328-*c.* 300	3303-3364
Carne	*c.* 328-*c.* 320	2439-3430
Marathus	*c.* 323-*c.* 300	P159-P167 and 3434-3451
Byblus	*c.* 330-*c.* 320	3421-3428
Berytus	*c.* 323-*c.* 320	3406-3420
Sidon	333-306/5	3456-3526
Tyre (ex 'Ake')	*c.* 330-305/4	3238-3302
Tyre	*c.* 305-290	3528-3562

Fig. 3. Phoenician mints of Alexander with references to Price 1991.

Mediterranean passed through this area, as through the western coastal area of Asia Minor. The output of the mints studied by Thompson and Duyrat left no doubt about this[23].

During the last quarter of the 4th century, no fewer than seven mints in the region issued Alexanders, assuming that Lemaire is correct in attributing the coins attributed by Price to "Ake" to Tyre (fig. 3)[24].

There is no die study of the Alexander tetradrachms issued by the Phonician mints except for Aradus. The figures for the latter mint are impressive: after Alexander's death, his successors used not fewer than 184 tetradrachm obverse dies in Aradus. There is no possibility to compare Aradus with Tyre or Sidon since there is no complete die-study of those two mints. However, the examination of the number of coins found in hoards can give an indication of output. From 325-320 BC, the Alexanders are massively represented in hoards of the Levant and in Egypt[25]. A study of all the eastern hoards published before 2000 in *IGCH* and *CH* shows that the Alexanders of Aradus are the most numerous (35 hoards, 567 coins), just ahead of Tyre (28 hoards, 532 coins), the discrepancy being due to the abundance of Aradian coins in the Demanhur hoard. Sidon appears in 20 hoards with 236 coins. Tyre and Aradus are also the mints best represented in hoards (11 hoards each)[26]. The volume and the area of dispersion of these two mints are very similar[27].

The analyses of Alexanders struck at Aradus, Byblus, and Sidon are shown in fig. 4. The results obtained for Tyre and Sidon during the Achaemenid period have not been added because the coins were analysed by Fast Neutron Activation Analysis (FNAA) and bismuth could not be determined with this method[28]. The quantity of gold found in those silver coins was, however, also between 2500 and 5000.

23 Thompson 1983 and Thompson 1991; Duyrat 2005a, 215.
24 Lemaire 1976; Duyrat forthcoming with references.
25 Duyrat forthcoming (Syria); Duyrat 2005b, 33-34 (Egypt).
26 Duyrat 2005a, 218.
27 Duyrat forthcoming.
28 Elayi *et al.* 2007 (Sidon); Elayi *et al.* 2008 (Tyre).

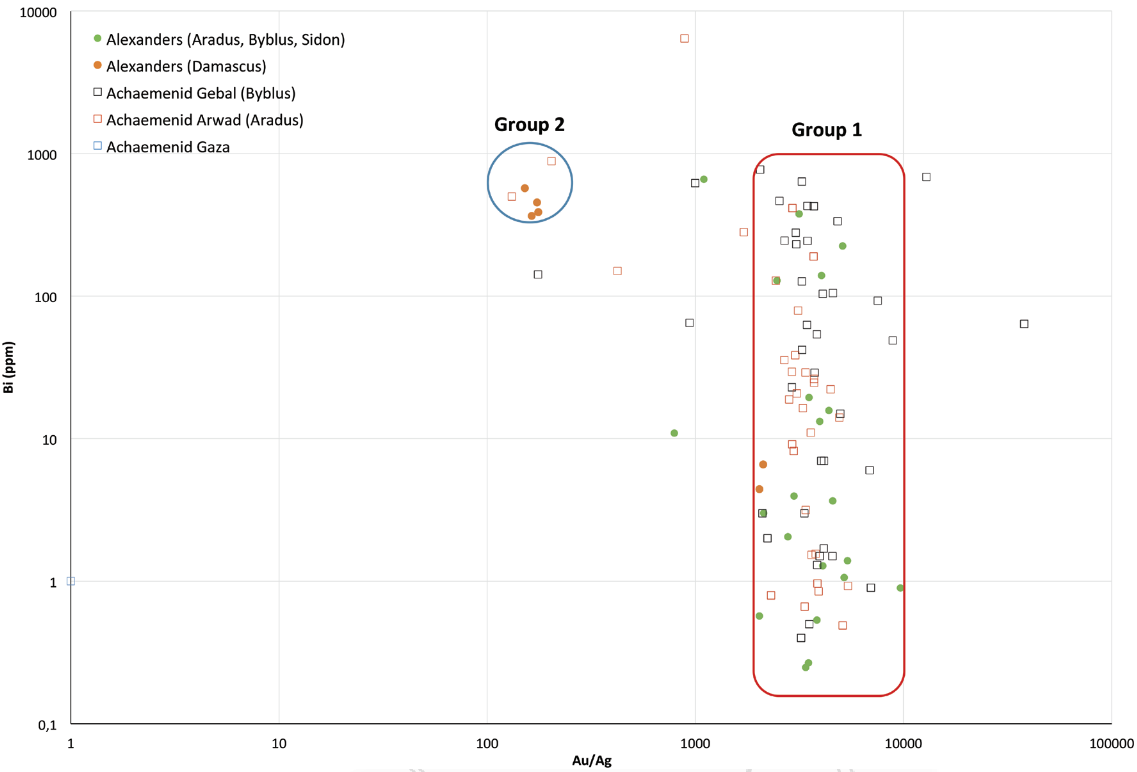

Fig. 4. Bismuth (Bi) content against gold to silver (Au/Ag) ratio for Achaemenid coins of Aradus, Byblus, and Gaza and Alexanders struck at Aradus, Byblus, Sidon, and Damascus (5th century-c. 300 BC), (logarithmic scale).

Whatever the turmoil of the times, no change is noticeable during Alexander's conquest. All the coins, Achaemenid and Hellenistic, show the same ratios of gold/silver, between 2000 and 5500 ppm, with a highly variable amount of bismuth (group 1 in fig. 4). This creates a column effect on the logarithmic graph. Interestingly, several coins with owl types issued in Gaza in the 4th century also share the same characteristics. A small group of Alexanders of Damascus and several coins from coastal mints is apart with 130-200 ppm of gold and 350 and 900 ppm of bismuth (group 2). The whole graph shows no noticeable change in the characterisation of the silver issues of the coastal mints before the Macedonian conquest but a more detailed examination of the content of 4th century coins allows two groups to be distinguished. Fig. 5 highlights the evolution of the bismuth content of Phoenician Alexanders. Five of the 21 Alexanders (fig. 5) have a bismuth content from *c.* 100 to 772 ppm. These results match the bismuth content of several coins from Arwad but above all those of 5th century silver coins from Byblus (fig. 4). The characteristics of this group with high bismuth content (*c.* 100-*c.* 800 ppm) seem to fade during the 4th century. But if we take a look at the evolution of bismuth content in Alexanders, we observe that all the high values are concentrated in the earliest issues, from *c.* 330 to *c.* 320. Thus, the first Alexanders show trace elements consistent with the metal of both the 5th century Phoenician coins and a smaller group dating to the 4th century. How should we interpret such an evolution? Those

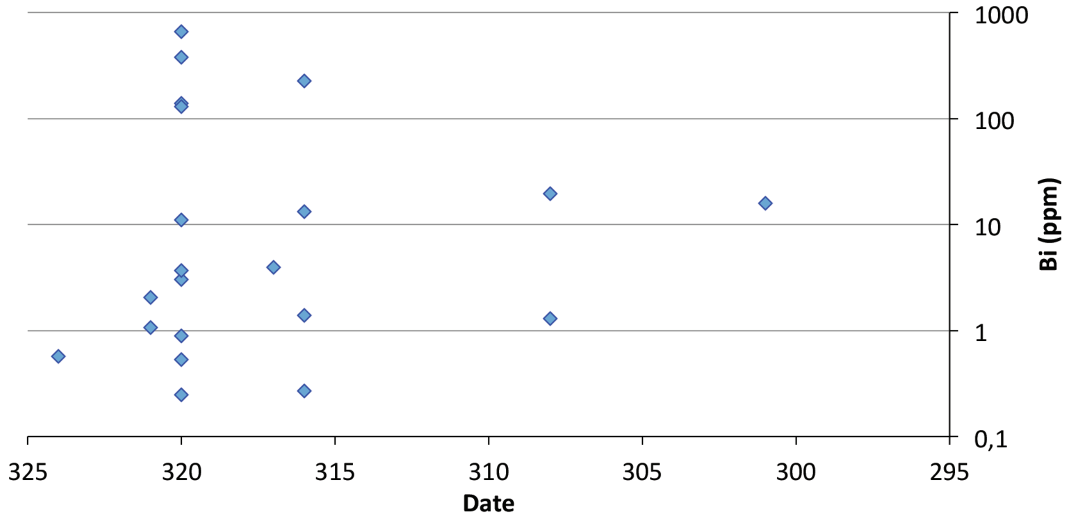

Fig. 5. Evolution of bismuth (Bi) content in Phoenician Alexanders.

early Alexanders might have been struck with the metal seized in regional treasuries during the conquest of the region, such as the treasury of Damascus taken by Parmenion[29], or those seized after the siege of Tyre. The metallic stocks hoarded in palaces or sanctuaries were available for immediate striking. The characteristics of different local stocks would therefore be recognisable in the Alexanders struck in Phoenicia.

Macedonia

The kingdom of Macedonia remained at the heart of the monetary organisation of Alexander's empire with a huge increase in gold and silver coin production from the end of the 320s. At that time, the kingdom already had a long monetary tradition, especially with regard to silver issues. Alexander I struck the first coins at Pella in the 460s or 450s[30], but the output remained fairly modest until the reign of Philip II, who inaugurated a new large silver coinage struck according to the "Thraco-Macedonian" standard in Pella and Amphipolis with no fewer than 544 dies counted by Le Rider between *c.* 356 and *c.* 328[31]. This change of scale, probably occurring around 349/348, is generally linked to the acquisition of the rich mines of Pangeion: their abundant production of gold and silver would have permitted the issuing of large precious metal coinages. The striking of coins with the types of Philip II continued during the reign of Alexander, simultaneously with the Attic standard silver coinage with types of the conqueror after 333/332 BC[32].

29 Arr. 2.11.10; 15.10; Curt.3.12.27 and 3.13. Sartre 2001, 69-70. See Glenn, this volume.
30 Kraay 1977, 190-193 on Price & Waggoner 1975; Price 1987, 45.
31 Le Rider 1977.
32 Le Rider 1977, 387-389; Troxell 1997.

From a monetary-circulation point of view, Macedonia has a very different profile from Phoenicia. The numerous hoards buried in the last third of the 4th century in the region, more broadly speaking in the Greek peninsula, seem to indicate a large movement of Alexanders from the eastern mints of Asia Minor, Babylon and Phoenicia to the West (fig. 6)[33]. This massive arrival of silver coins accompanied a considerable increase of the silver coin production of the Macedonian mints, especially in Amphipolis. As for Macedonian gold issues, a change of the metal stock is expected.

Region	Hoards	%
Greece	106	76%
Macedonia and the North	43	
Thrace and Western Euxine	143	
Asia Minor	15	24%
Cyprus	15	
Levant and the East	49	
Egypt	12	
Total	383	100%

Fig. 6. Silver hoards from c. 330 to c. 300 BC[33].

The coins have been divided according to their types, places, and periods of issues. Such a distribution is necessary to show the division between mints after 323 BC. Coins struck before this date at Pella and Amphipolis share the same metal characteristics and appear to come from the same stock, characterised by bismuth contents below 500 ppm (fig. 7, group 1). More precisely, of 34 coins in group 1, 29 coins are under c. 500 ppm, of which 20 are under 100 ppm. But after the end of the conquest, two different stocks of metal can be determined. The Philips and Alexanders struck in Pella seem to come from a silver stock similar to the one used to strike Philips before 328 BC (group 1) while Amphipolis issues *c.* 323-*c.* 300 BC show a higher – sometimes much higher – amount of bismuth (group 2), almost always greater than 500 ppm. The distinction of a new stock of silver confirms what Diodorus says of monetary supplies sent by Alexander to Macedonia: in 323 BC, Antipater led an army from Macedonia against the rebellion of the Greeks, "accompanied by the entire fleet which Alexander had sent to convoy a sum of money (χρημάτων) from the royal treasury to Macedonia, being in all one hundred and ten triremes"[35]. Χρήματα can have a number of meanings. In this case, nothing points to coined metal and we may imagine raw metal in whatever form, especially if it came straight from Eastern treasuries in areas where coins

33 Duyrat 2016, 442-448.

34 *IGCH*, *CH* 1-10.

35 ὃν ἀπεσταλκὼς ἦν Ἀλέξανδρος παραπέμψοντα πλῆθος χρημάτων ἐκ τῶν βασιλικῶν θησαυρῶν εἰς τὴν Μακεδονίαν, οὐσῶν τῶν πασῶν τριήρων ἑκατὸν καὶ δέκα… D.S. 18.12.2 (R. M. Geere, Loeb).

were not common: Alexander sent them from Babylon. P. Goukowsky proposed to link this supply of χρήματα to the Harpalus affair, which would date it *c.* 324 BC[36]. If these χρήματα were taken to the mint of Amphipolis and struck there without being mixed with other bullion stocks, it would explain the distinctive characteristics of metal we have identified. It would also qualify Holt's opinion, who considers that "Alexander sent a relatively small portion of the Persian bullion to Macedonia: Curtius 3.1.20 and Diodorus 18.12.2"[37]. As the silver characteristics of Amphipolis are unique, we should consider that the 110 ships contained enough silver to fuel the most productive mint of the Empire. They were sent at the very end of the reign, just before the death of Alexander. Le Rider highlights how welcome they were at a time Antipater had to face the expenses of the Lamian war (323/322 BC), before participating in the beginning of the successors' wars[38]. He also notices that minting could be very intensive if needed and that the 241 obverse dies of the largest group of issues of that period (Troxell 1997, group E) could have been used in only several months[39].

Amphipolis is also isolated from other mints because elemental and metallurgical analysis revealed a slightly lower silver content than at other mints, about 2 % less (fig. 8)[40]. These data must be linked with the importance of Amphipolis' silver production within the Empire. The PELLA portal that gathers the main institutional collections in the world links to 2,604 silver coins struck in Amphipolis, mostly tetradrachms (2,465)[41]. This represents more than 15 % of all the silver Alexanders on the portal, while no fewer than 101 lifetime and posthumous mints issuing this metal are recorded[42]. Amphipolis represents five times the Pella mint (496 silver coins). Circulation studies point out the large dissemination of Amphipolis issues, especially in Greece, in Asia Minor, and in Egypt[43]. Partial die studies confirm this predominance: Amphipolis is by far the most prolific mint across the Empire with estimates suggesting between 875 and 1079 obverse dies of tetradrachms with Alexander types used between 332 and *c.* 310[44]. We can also estimate that between 752 and 1,194 dies were used in the production of coins in the huge Demanhur hoard buried around 318. From the same hoard, Newell deduced that Babylon was the second most productive mint with only 172-193 dies[45].

36 Goukowsky's comment on Diodorus, Collection des universités de France, Paris, 2002, 124.

37 Holt 2016, 245, n. 94. As a matter of fact, Alexander sent other subsidies to Antipater (Arr. 3.16.10), and it is doubtful that our sources give a complete record of the communication and support between Alexander and Macedonia. About the importance of Macedonia in Alexander's lifetime output on the basis of types and specimens in numismatics.org/pella, see the conclusion of Meadows in this volume.

38 Le Rider 2003, 97-98.

39 Le Rider 2003, 99.

40 This slightly lower content of silver is related to a higher concentration in lead and may be the consequence of the way the cupellation was conducted. See Flament *et al.* forthcoming.

41 Date of access: 10 August 2017.

42 See Olivier, this volume.

43 Duyrat 2005b, 28-29.

44 Estimation of the original number of obverse dies using Carter 1983 on the basis of the die study of Troxell 1997, 26.

45 Estimations of the original number of obverse dies using Carter 1983 on the basis of the die study of Newell 1923, 151.

In order to determine whether this phenomenon lasted long after *c.* 300, we chose to complete our sample by analysing 8 coins minted at Amphipolis between *c.* 294 and *c.* 270. They can be divided into two groups: the 4 earliest coins, dated to *c.* 294-290[46] and *c.* 287-283[47], still have rather high bismuth contents (c. 500-c. 1000 ppm), whereas the 4 latest tetradrachms, dated to *c.* 280-270[48], match the issues of Pella (fig. 7) perfectly.

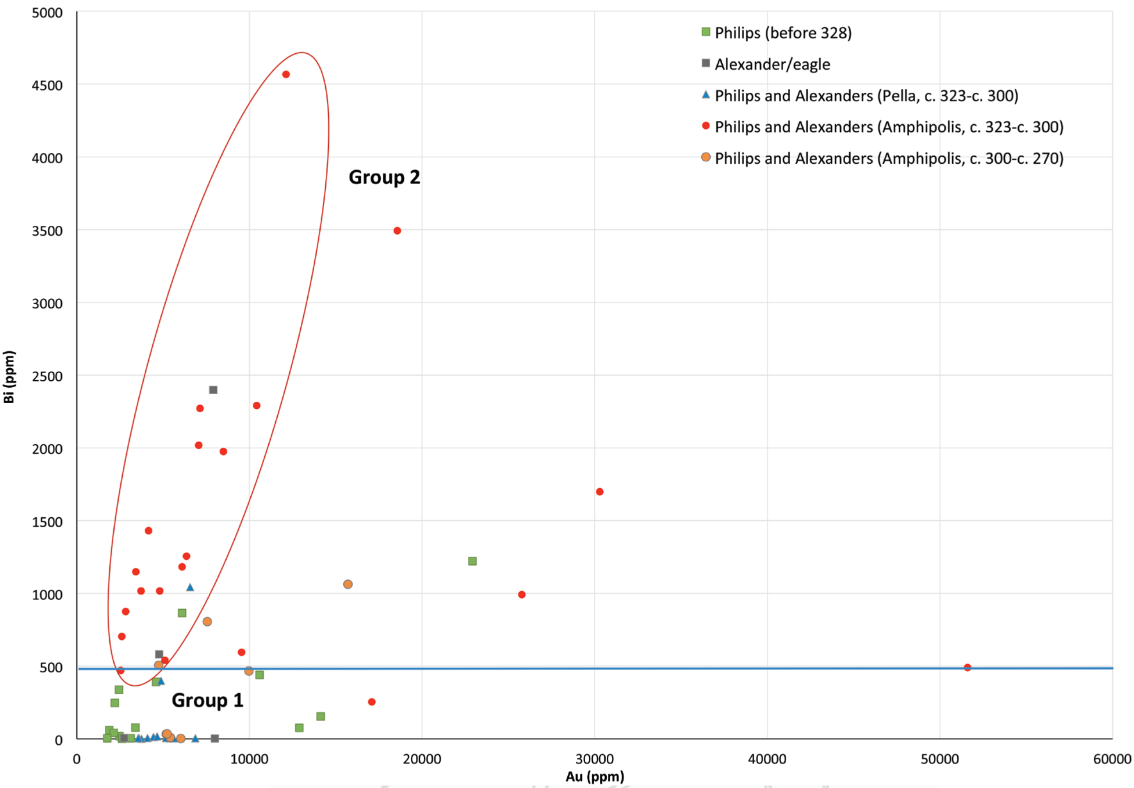

Fig. 7. Bismuth (Bi) content against gold to silver (Au/Ag) ratio for Macedonian coins (c. 359-c. 270).

Mints	Coins	Average silver content	Standard deviation
Babylonia	14	99,1%	0.23
Phoenicia	27	99,1%	0.38
Pella	12	98,7%	0.42
Amphipolis	21	97,0%	1.21

Fig. 8. Average silver content and standard deviation in Alexanders and Philips, c. 330-c. 300 BC.

46 Price n° 500, 502 and 507 var.
47 Price n° 537.
48 Price n° 611, 613, 615 and 616.

To sum up, the conquest made Amphipolis the most important silver mint across the Empire. Between *c.* 323 and *c.* 300, this mint used an alloy with a lower silver content (fig. 8)and was fuelled with a new metallic stock; the phenomenon came to an end during the 280s BC.

Across the Empire

As a whole, the analyses have not provided the result we would have found logical in the upheaval of the end of the Achaemenid Empire. The Macedonian conquest led to a dramatic monetary change in types, weights, and volume of issues. The metal used to issue the coins in Phoenicia, with local types in the Achaemenid period or with Alexander's type after 333, shows no significant change. On the contrary: there seems to be a homogenisation of the stock used by all the mints: the differences in bismuth content fade. There is no sign of a new stock of metal used to issue the coins with the types of Alexander. Surprisingly, Babylon shows the same profile: the metal of the Alexanders struck there has the same characteristics as the metal used by the Phoenician mints before and after Alexander (fig. 9), although Babylon was the second mint of Alexander's Empire. Even more surprisingly, Pella results fall in the same area. The conquest marks no upheaval in the composition of coins across the Empire and we notice no metal stock with new characteristics. The results obtained for Amphipolis tetradrachms *c.* 323 and *c.* 300 are in complete contrast with this "Empire silver".

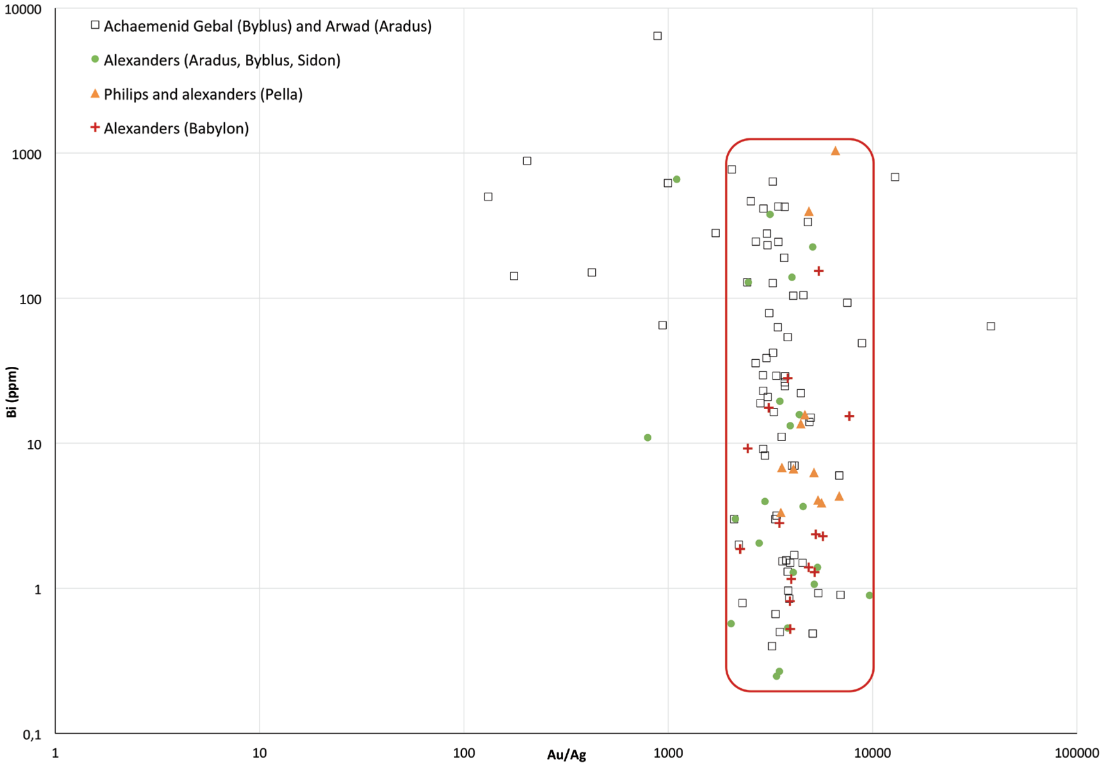

Fig. 9. Bismuth (Bi) content against gold to silver (Au/Ag) ratio for coins of Achaemenid Phoenicia, Babylon, and Pella.

We are clearly facing two different stocks of silver. At this stage, it seems necessary to broaden the scope to compare these results with the issues of classical Athens. The 46 Athenian silver coins analysed come from the collection of the Bibliothèque nationale de France and were found in the East: they come from the Marash – *IGCH* 1484 (10), Tell el-Maskhouta – *IGCH* 1649, *CH*, 10.441 (15), Asyut – *IGCH* 1673 (21), Baghdad 1957 – *IGCH* 1751 (3) and Karaman – 1398 (1) hoards, and 17 were "found in Egypt"[49]. We have also taken results from another study by Gale, Genter, and Wagner[50]. They performed analyses on other Archaic and Classical silver coins, but Athens is of particular interest for our study since the owls remained an international coinage during the 4th century and Athens' bullion production a major source of metal[51].

The contents of Athenian coins are variable, from 16 ppm to 3,013 of gold/silver and from *c.* 39 ppm to 2,219 ppm of bismuth in group 1 (fig. 10). However, the Athenian silver forms a rather coherent and distinct group from the others already identified. Fig. 10 shows that it has almost no common characteristics with the Phoenician and Babylonian coins (group 2),

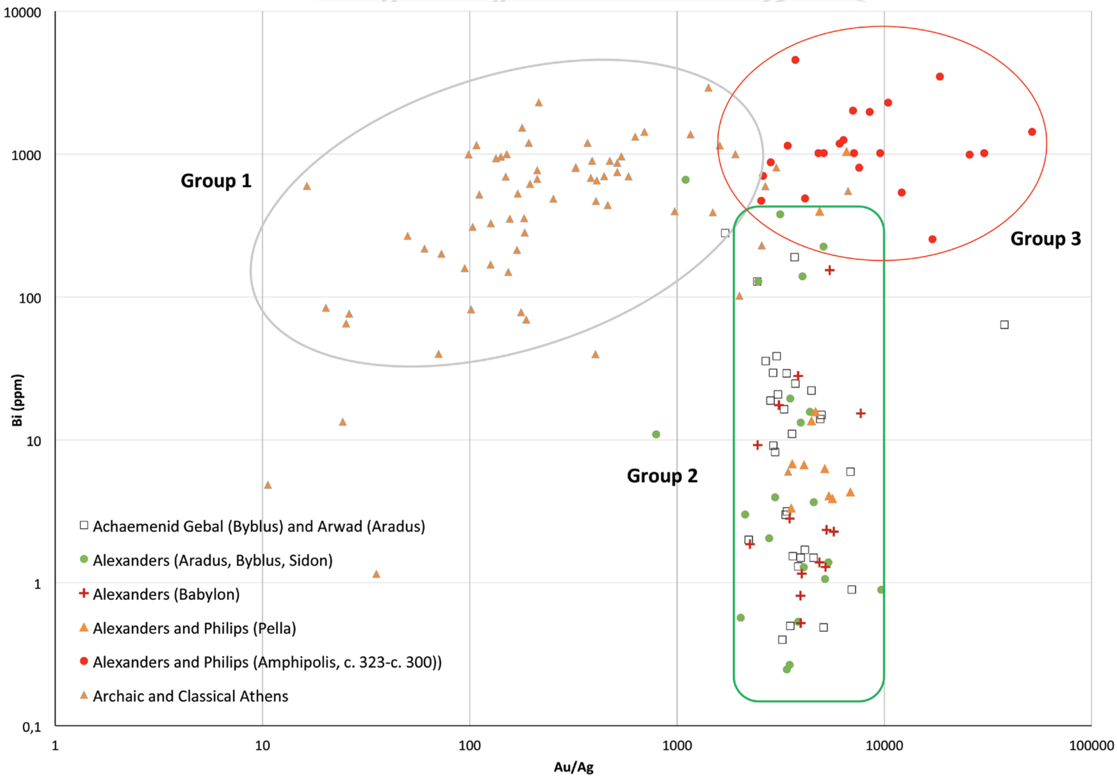

Fig. 10. Bismuth (Bi) content against gold to silver (Au/Ag) ratio for Greek silver coinages (6th-4th century BC), Philips and Alexanders (c. 330-300 BC), (logarithmic scale).

49 Faucher forthcoming.
50 Gale *et al.* 1980.
51 Duyrat 2016, 313-317.

although it would have seemed natural to imagine that the large number of Athenian owls circulating and hoarded in the Persian Empire could have been melted to strike tetradrachms with Alexander's types.

Surprisingly, the silver Philips struck in Pella before 328 share the same characteristics as the Eastern coins while scholars have generally considered that they were probably struck with the bullion of the Pangeion region. Gold issues with Philip's types of the same period have a distinctively different bullion than the issues later than 323 BC[52]. We must conclude that the issues of Amphipolis between *c.* 323 and *c.* 300 (group 3) correspond to nothing known in Athens, in the Achaemenid Empire or even in Macedonia before 323 BC.

Conclusion

We come to the question of the issue by Alexander of the stock of metal mentioned in ancient sources. In a famous passage, Herodotus described the Persian practice of melting down the metal they received as a tribute[53]. Much has been written on this. Holt recently provided a detailed evaluation of the amounts of metal captured by Alexander while he was conquering the satrapies according to written sources[54]. The existence of huge stocks of precious metal is not in doubt. There are also numismatic data confirming the upheaval that the Macedonian conquest created in coin production and circulation. In the mints benefiting from a die study, we see that the volume of issues increases significantly[55] and earlier coinages disappear from hoards in the East and in Egypt, replaced by Alexanders in vast quantities[56]. A study comparing the trace elements of gold found in Eastern coins, from the Croeseids to the issues of the Seleucids and the Ptolemies, has also shown that there was an Eastern characterisation with a broad spectrum fitting the idea of the destocking of large quantities of metal by Alexander[57].

In such a context, how can we explain that, from Babylon to Pella, the silver of the coins analysed in this paper, issued before and after Alexander, forms a group with the same characteristics? Can we imagine that the huge amounts of metal kept in the Persian satrapies had the same characterisation as the metal circulating as coins? Amphipolis' distinctiveness points to an answer explaining the discrepancy between the visible effect of issues in the name of Alexander for gold and the puzzling situation for silver.

Gold was not such a commonly coined metal before Alexander, especially in the East where not a single mint struck that metal before the Macedonian conquest. On the contrary, silver circulated widely and in significant quantities from the 6th century BC onwards. The first currencies used in Achaemenid Syria came from the Thraco-Macedonian area and

52 Guerra & Gondonneau 2000.
53 Hdt. 3.96.
54 See Holt 2016, esp. 164-166.
55 Thompson 1983; Thompson 1991; Troxell 1997; Duyrat 2005a.
56 Duyrat 2005b; Duyrat 2016, 332-339.
57 Duyrat & Olivier 2010.

were replaced by Athenian owls in large quantities[58]. During the 5th century, Eastern mints started issuing their own coinages, which slowly replaced foreign currencies. Phoenician coins became more common than Athenian owls in the hoards of the 4th century buried in Syria[59]. Metal travelled during the Achaemenid period, sometimes over long distances. This may explain the fact that Babylon and the Phoenician mints under the Achaemenids, and these same mints and Pella after Alexander, struck stocks of metal already in circulation from the Aegean to the East. We should imagine that the characterisation of silver shown by the large group 1 in fig. 7 reflects a wide circulation of the stock of silver before Alexander. It emphasises the peculiarity of the silver stock minted by Amphipolis between *c.* 323 and *c.* 300.

The issues of Amphipolis are by far the most spectacular of all the mints striking coins with Alexander's type. The location of the mint, at the Eastern border of Macedonia, close to the Thracian sources of metal, encouraged Le Rider, Price, and Troxell to confirm the attribution to that city. For those very reasons, de Callataÿ has even noted that "It is no less evident that not all the Alexanders were coined with the only metal of the booty taken from Darius III Codoman. In particular, forty years of mining at Mount Pangeion may have brought about a considerable amount of gold and silver. So the main Macedonian workshop – whether Amphipolis or Pella – may well have remained completely independent of Persian treasures in terms of its metal supply"[60]. Unexpectedly, the analyses of the metal may lead us to an opposite conclusion: the characterisation of the silver used by Amphipolis, completely separate from the usual Eastern metal, could be interpreted as the signature of a new stock of metal, directly taken from Ecbatana to supply the needs of the Amphipolis mint.

58 Duyrat 2016, chap. 4.

59 Duyrat 2016, 315, fig. 4.7.

60 Callataÿ 1989, 273. "Il est non moins évident que tous les alexandres n'ont pas été monnayés avec le seul métal des butins pris à Darius III Codoman. En particulier, quarante années d'exploitation minière du Mont Pangée peuvent avoir amené une masse appréciable d'or et d'argent. Aussi, le principal atelier macédonien — qu'il s'agisse d'Amphipolis ou de Pella — peut fort bien être resté parfaitement indépendant des trésors perses pour ce qui est de son approvisionnement métallique".

Appendix: Results of elemental analysis by LA-ICP-MS:

Inventory n° (BnF, MMA)	Mint	Denomination	Bibliography	Ag (%)	Cu (%)	Pb (%)	Au/Ag	Bi (ppm)
Philips								
FG 177	Amphipolis	Tetradr.	Le Rider 1977, gr. 1, p. 78, n° 56, pl. 25	98.71	0.05	0.55	6,094	864
FG 175	Amphipolis	Tetradr.	Le Rider 1977, gr. 1, p. 80, n° 72, pl. 26	98.37	0.16	0.18	12,892	75
FG 182	Amphipolis	Tetradr.	Le Rider 1977, gr. 1, p. 87, n° 153, pl. 29	98.39	0.11	0.40	10,585	440
Delepierre 955	Amphipolis	Tetradr.	Le Rider 1977, gr. 1b, p. 88, n° 158a, pl. 29	99.33	0.16	0.19	3,121	4
1972.940	Amphipolis	Tetradr.	Le Rider 1977, gr. 2, p. 90, n° 178, pl. 30	97.46	0.03	0.15	22,914	1,222
1965.1039	Amphipolis	Tetradr.	Le Rider 1977, gr. 2, p. 91, n° 183, pl. 30	99.18	0.02	0.29	4,591	391
1967.278	Amphipolis	Tetradr.	Le Rider 1977, gr. 2, p. 96, n° 243, pl. 33	98.43	0.05	1.32	1,892	59
FG 234	Amphipolis	Tetradr.	Le Rider 1977, gr. 3, p. 121, pl. 44	98.79	0.10	0.55	4,152	1,430
1971.344	Amphipolis	Tetradr.	Le Rider 1977, gr. 3, p. 123, pl. 45, 14	97.05	0.46	1.42	9,546	595
Delepierre 964	Amphipolis	Tetradr.	Le Rider 1977, gr. 3, p. 123, pl. 45, 12	93.73	0.04	1.34	51,606	490
FG 210	Amphipolis	Tetradr.	Le Rider 1977, gr. 3, p. 123, pl. 46, 4	98.27	0.08	1.18	3,721	1,015
FG 213	Amphipolis	Tetradr.	Le Rider 1977, gr. 3, p. 124, pl. 46, 18	97.79	0.16	1.46	4,807	1,016
FG 200	Amphipolis	Tetradr.	Le Rider 1977, gr. 4, p. 125, pl. 47, 7	95.52	0.10	1.31	30,292	1,697
FG 201	Amphipolis	Tetradr.	Le Rider 1977, gr. 4, p. 125, pl. 47, 2	96.15	0.19	2.74	7,144	2,271
Delepierre 966	Amphipolis	Tetradr.	Le Rider 1977, gr. 4,p. 125, pl. 47, 1	97.30	0.17	0.88	12,128	*4,566*
M 5078	Amphipolis	1/5 tetradr.	Le Rider 1977, gr. 4, p. 126, pl. 48, 8	93.07	5.97	0.38	5,110	539
FG 180	Pella	Tetradr.	Le Rider 1977, gr. 1, p. 10, n° 37, pl. 2	99.21	0.27	0.25	2,659	3.5
1965.1040	Pella	Tetradr.	Le Rider 1977, gr. 1, p. 16, n° 92, pl. 4	99.34	0.00	0.38	2,194	247
1971.252	Pella	Tetradr.	Le Rider 1977, gr. 1, p. 8, n° 21, pl. 1	99.40	0.02	0.16	2,443	337
FG 179	Pella	Tetradr.	Le Rider 1977, gr. 1, p. 10, n° 40a, pl. 2	99.05	0.01	0.62	2,625	0.8
Delepierre 954	Pella	Tetradr.	Le Rider 1977, gr. 1, p. 20, n° 135b, pl. 6	99.69	0.04	0.04	2,139	*42*
R 3778	Pella	Tetradr.	Le Rider 1977, gr. 2, p. 25, n° 166c, pl. 7	99.38	0.31	0.13	1,768	4
FG 186	Pella	Tetradr.	Le Rider 1977, gr. 2, p. 34, n° 236, pl. 10	99.14	0.08	0.43	3,390	78
FG 214	Pella	Tetradr.	Le Rider 1977, gr. 2, p. 55, n° 427c, pl. 18	98.54	0.01	0.03	14,129	154
FG 184	Pella	Tetradr.	Le Rider 1977, gr. 3, p. 57, n° 439, pl. 18	99.38	0.14	0.10	3,744	0.05
FG 185	Pella	Tetradr.	Le Rider 1977, gr. 3, p. 61, n° 470, pl. 20	98.90	0.17	0.56	3,600	7
1968.35	Pella	Tetradr.	Le Rider 1977, gr. 3, p. 67, n° 528b, pl. 22	97.56	0.63	1.28	4,882	398
Eagle Coinage								
K 1044	Macedonia	Tetradr.	Price 1991, 143	98.68	0.19	0.34	7,992	3.1
AA.GR.10471	Macedonia	Drachm	Price 1991, 145	97.82	0.07	1.08	7,902	2,398
1973.1.66	Macedonia	Drachm	Price 1991, 153	99.16	0.23	0.33	2,738	5.2
R 4277	Macedonia	Fraction	Price 1991, 155	97.98	0.08	1.40	4,776	580
Alexanders in the name of Alexander the Great								
FG 692	Amphipolis	Tetradr.	Price 1991, 4	98.14	0.04	1.45	2,833	875
Y 27	Amphipolis	Tetradr.	Price 1991, 59	96.07	0.04	3.17	6,094	1,182
FG 604	Amphipolis	Tetradr.	Price 1991, 129	98.47	0.07	0.39	8,487	1,976
FG 610	Amphipolis	Tetradr.	Price 1991, 131	97.11	0.39	1.74	6,362	1,256
Seymour de Ricci 1595	Amphipolis	Tetradr.	Price 1991, 131	98.17	0.27	1.19	2,603	704
FG 621	Amphipolis	Tetradr.	Price 1991, 132	96.17	0.96	1.46	10,419	2,291

FG 631	Amphipolis	Tetradr.	Price 1991, 140	97.84	0.59	0.65	7,071	2,018
FG 547	Amphipolis	Tetradr.	Price 1991, 451A	98.65	0.18	0.70	3,415	1,148
Delepierre 988	Amphipolis	Tetradr.	Price 1991, 432	96.79	0.23	0.82	18,560	3,492
FG 528	Amphipolis	Tetradr.	Price 1991, 459	95.94	0.16	1.32	25,785	991
FG 524	Amphipolis	Tetradr.	Price 1991, 468	97.52	0.11	0.67	17,089	254
FG 533	Amphipolis	Tetradr.	Price 1991, 474	98.77	0.05	0.87	2,553	471
FG 572	Amphipolis	Tetradr.	Price 1991, 500	98.05	0.05	1.07	7,566	805
FG 573	Amphipolis	Tetradr.	Price 1991, 502	98.76	0.17	0.53	4,739	506
FG 997	Amphipolis	Tetradr.	Price 1991, 507 var.	98.20	0.10	0.66	9,968	467
FG 1009	Amphipolis	Tetradr.	Price 1991, 537	97.57	0.13	0.64	15,703	1,063
R 4123	Amphipolis	Tetradr.	Price 1991, 611	98.96	0.18	0.32	5,406	10
FG 742	Amphipolis	Tetradr.	Price 1991, 613	98.48	0.23	0.71	5,232	35
FG 741	Amphipolis	Tetradr.	Price 1991, 615	98.73	0.18	0.56	5,175	34
FG 741A	Amphipolis	Tetradr.	Price 1991, 616	99.04	0.16	0.20	6,026	1.6
Delepierre 990	Pella	Tetradr.	Price 1991, 214	99.29	0.17	0.12	4,098	6.7
FG 425	Pella	Tetradr.	Price 1991, 232 var.	98.51	0.19	0.94	3,561	3.3
1972.959	Pella	Tetradr.	Price 1991, 233A	99.19	0.05	0.19	5,622	4
R 2925	Pella	Tetradr.	Price 1991, 248	99.04	0.12	0.14	6,873	4
Luynes 1645	Pella	Tetradr.	Price 1991, 249	97.86	0.21	1.17	6,572	*1,043*
R 4126	Pella	Tetradr.	Price 1991, 559	98.74	0.29	0.45	5,164	6.3
FG 956	Pella	Tetradr.	Price 1991, 566	98.80	0.34	0.32	5,399	4.1
FG 948A	Pella	Tetradr.	Price 1991, 574	99.08	0.15	0.30	4,661	16
R 4456	Pella	Tetradr.	Price 1991, 592	98.52	0.39	0.64	4,451	14
FG 900	Damascus	Tetradr.	Price 1991, 3203	99.57	0.05	0.30	152	573
Delepierre 1005	Damascus	Tetradr.	Price 1991, 3207	99.72	0.04	0.18	176	389
FG 899A	Damascus	Tetradr.	Price 1991, 3208	99.61	0.08	0.24	174	454
FG 899	Damascus	Tetradr.	Price 1991, 3210	99.54	0.18	0.06	2,116	6.6
Delepierre 1004	Damascus	Tetradr.	Price 1991, 3211	99.71	0.06	0.17	164	365
Luynes 1632	Damascus	Tetradr.	Price 1991, 3211	99.61	0.09	0.09	2,031	4.4
FG 904	Aradus	Tetradr.	Price 1991, 3309	99.18	0.14	0.46	2,131	3
Delepierre 1007	Aradus	Tetradr.	Price 1991, 3316	99.47	0.10	0.09	3,385	0.2
1981.244	Aradus	Tetradr.	Price 1991, 3321	99.26	0.22	0.11	3,836	1
N4300	Aradus	Tetradr.	Price 1991, 3332	99.60	0.10	0.21	792	11
FG 931	Aradus	Tetradr.	Duyrat 2005a, gr. VI	99.30	0.20	0.06	4,378	16
FG 911	Byblus	Tetradr.	Price 1991, 3424	99.01	0.27	0.37	3,146	379
Y 44	Byblus	Tetradr.	Price 1991, 3424	99.27	0.13	0.17	4,037	140
Vogüé 265	Byblus	Tetradr.	Price 1991, 3426	99.13	0.19	0.42	2,463	129
H 79	Sidon	Tetradr.	Price 1991, 3487	99.32	0.17	0.30	2,030	0.6
FG 917	Sidon	Tetradr.	Price 1991, 3498	99.34	0.16	0.21	2,784	*2*
Fouilles de Suse 507	Sidon	Tetradr.	Price 1991, 3498?	99.26	0.06	0.13	5,177	*1.1*
1974.385	Sidon	Tetradr.	Price 1991, 3521	99.47	0.10	0.06	3,518	20
1974.386	Sidon	Tetradr.	Price 1991, 3521	98.87	0.54	0.17	4,091	1.3
FG 704	Babylon	Didrachm	Price 1991, 3582	99.48	0.10	0.17	2,448	9
Y 31	Babylon	Tetradr.	Price 1991, 3599	99.39	0.10	0.11	3,837	28

Alexanders in the name of Alexander the Great									
Seymour 1602	Babylon	Tetradr.	Price 1991, 3692	99.17	0.14	0.17	5,206	1.3
B 734	Babylon	Hémidr.	Price 1991, 3694	99.20	0.16	0.15	4,871	*1.4*
1973.1.415	Babylon	Shekel?	Price 1991, 3706	98.85	0.15	0.22	7,703	15
FG 682	Babylon	Tetradr.	Price 1991, 3708	99.30	0.16	0.31	2,248	*1.9*
S. de Rotschild 14	Babylon	Tetradr.	Price 1991, 3713	99.03	0.22	0.18	5,445	154
Waddington 7202	Babylon	1/30th dr.	Price 1991, 3729	99.14	0.21	0.16	3,101	18
FG 684	Babylon	Tetradr.	Price 1991, 3759	99.11	0.28	0.25	3,496	3
FG 683	Babylon	Tetradr.	Price 1991, 3763	99.08	0.27	0.25	3,943	0.8
Delepierre 1022	Babylon	Tetradr.	Price 1991, 3765	99.16	0.17	0.14	5,262	2.4
Alexanders in the name of Philip Arrhidaeus									
FG 1134	Aradus	Tetradr.	Price 1991, P141	99.19	0.15	0.11	5,372	1
FG 1144	Aradus	Tetradr.	Price 1991, P152	95.67	3.47	0.32	5,092	225
FG 1136	Aradus	Tetradr.	Price 1991, P153	99.22	0.19	0.18	3,956	13
FG 1139	Aradus	Tetradr.	Price 1991, P155-6	99.16	0.11	0.37	3,494	0.3
FG 1152 A	Sidon	Tetradr.	Price 1991, P169	98.40	0.18	0.46	9,672	1
FG 1152	Sidon	Tetradr.	Price 1991, P169	99.05	0.12	0.38	4,566	3.7
1969.420	Sidon	Tetradr.	Price 1991, P175	98.76	0.21	0.84	1,099	661
Vogüé 358	Sidon	Tetradr.	Price 1991, P177	99.35	0.12	0.22	2,973	4
FG 1146	Babylon	Tetradr.	Price 1991, P181	99.35	0.14	0.10	4,002	1.2
S. de Rotschild 13	Babylon	Tetradr.	Price 1991, P181	99.32	0.12	0.16	3,954	*0.5*
FG 1156	Babylon	Tetradr.	Price 1991, P205	97.87	0.31	1.25	5,709	2

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