

MINING MONEY IN LATE ARCHAIC ATHENS*

ABSTRACT: Silver mining helped transform Athens from a quiet backwater ca. 600 BCE to a dominant regional and naval power a little over a century later, but despite having large argentiferous ore deposits and being an early minter, she did not initially use much native silver for her coinage. In this paper I identify technical and geopolitical factors which explain this. I also explore the related and controversial questions of the extent to which the Athenian State benefited from the subsequent massive exploitation of the Laurion deposits, and the nexus between silver mining, monetisation of the economy, and political development.

1. Introduction

In the second half of the sixth century, silver was the principal metal from which ancient Greek coinage was made; to mine silver was quite literally to mine money. Silver-bearing ore was only available in commercially-useful quantities in a few locations in the Aegean, and the most important of these were Thracio-Macedonia (including Thasos) and Attica.¹

* This paper incorporates research undertaken during my PhD which now forms part of an Australian Research Council grant (DP 120103519) – details in K. Sheedy, D. Gore & G. Davis, ‘“A Spring of Silver, a Treasury in the Earth”: Coinage and Wealth in Archaic Athens’, in J. Burness & T. Hillard (Eds.), *Australian Archaeological Fieldwork Abroad II*, 39/2 (2009) 248–57. I offer my sincere thanks to Professor J. H. Kroll, Professor J. K. Davies, Professor P. J. Rhodes, Associate Professor G. R. Stanton, Associate Professor K. A. Sheedy, Dr. D. J. Phillips, Dr. J. Ross, Dr. P. Acton, and Dr. Z. H. Archibald for their invaluable feedback and access to unpublished work. I also appreciate the acute observations and suggestions of *Historia*’s Readers, but responsibility for the content rests with me. All dates are BCE unless otherwise stated.

1 Other Aegean islands had small quantities of silver. Z. Stos-Gale, N. Gale & N. Annetts, ‘Lead Isotope Data from the Isotrache Laboratory, Oxford: *Archaeometry* Data Base 3, Ores from the Aegean, Part 1’, *Archaeometry* 38 (1996) 381–90 noted the presence of ancient litharge (the by-product of cupellation of argentiferous lead to extract silver) on Siphnos, Seriphos, Kea and Thera, but little is known of their ancient exploitation except for Siphnos, and her silver was virtually depleted by the late sixth century, cf. Hdt. 3.57–8. The relatively minor importance of Siphnian silver can be assessed by Herodotos’ tale in which the accumulated sum of Siphnian wealth at the end of productive mining ca. 524 was only the 100 talents extorted by the Samians (presumably they would have got more if they could), plus some civic building expenditure. The fact that her mint produced ‘insignificant’ coinage in the archaic period as both J. Price, ‘The Uses of Metal Analysis in the Study of Archaic Greek Coinages: Some Comments’, in D. Metcalf & W. Oddy (Eds.), *Metallurgy in Numismatics*,

The abundant resources of the Athenians were described by Aischylos (*Persians* 238) as ‘a fountain of silver, a treasure in their soil’,² but the fountain really only started to flow in the late-sixth century. The reasons for this and the effects on the Athenian economy and political development are not well understood – they are the subjects of this paper.

We can reasonably assume that the Athenian tyrant Peisistratos (and his sons) came to understand the importance of *chrēmata* (literally ‘useful things’, but in this context translated as ‘money’ including wealth generally) from his abortive early attempts at tyranny. He required money to pay for external military support to defeat his aristocratic opponents (Hdt. 1.62.2–63.2) and maintain control over them (Hdt. 1.64.1). In the period of his second exile (557/6 or 556/5?–546/5?),³ he actively collected funds from debtors and donors (Hdt. 1.61.3–4; 1.62.2). Arguably he went to Thrace precisely because it was there that he could most readily obtain money from mining and employ mercenaries (Hdt. 1.64.1; *Ath. Pol.* 15.2). Later he used money and the power it gave him for overseas operations (Hdt. 5.94.1 – defence of Sigeion; 1.64.2 – conquest of Naxos and religious activities on Delos [cf. Thuc. 3.104.1]; 6.35–41 – overlordship of the Chersonese), an ambitious building program (Thuc. 6.54.5),⁴ and patronage of the arts.⁵ The escalating scale of these expenditures was clearly dependent upon ever greater income, and the naval operational component must have been particularly expensive.⁶

Mining is generally assumed to have formed a significant part of the cash-flow of the Peisistratids based on Herodotos’ statement (1.64.1) that they were ‘drawing increased revenues [*chrēmata*] both from Attica itself and from the region of the River Strymon’.⁷ The assumption that the Attic part of their revenues was also derived from mining need not be correct (though it is implied in the Greek) given the references to taxation of the

Vol. 1 (London 1980) 51 and more recently Z. Stos-Gale, ‘The Impact of the Natural Sciences on Studies of *Hacksilber* and Early Silver Coinage’, in M. Balmuth (Ed.), *Hacksilber to Coinage: New Insights into the Monetary History of the Near East and Greece* (New York 2001) 60 noted, is probably reflective of this. Cf. also K. Sheedy, *The Archaic and Early Classical Coinages of the Cyclades* (London 2006), chapter on Siphnos. Direct Greek access to the silver of Spain and Etruria was cut off (or at least seriously diminished) following the Battle of Alalia in the early 530s, and silver mined in Asia Minor was presumably retained in the Persian Empire.

- 2 This quotation provided the inspiration for the name of the project in which I am engaged, part entitled, ‘A spring of silver, a treasury in the earth: coinage and wealth in Archaic Athens’.
- 3 Following P. J. Rhodes, *A Commentary on the Aristotelian Athenaion Politeia* (Oxford 1981) 198, Table 2.
- 4 J. Boersma, *Athenian Building Policy from 561/0 to 405/4 B.C.* (Groningen 1970); J. Boersma, ‘Peisistratos: Building Activity Reconsidered’, in H. Sancisi-Weerdenburg (Ed.), *Peisistratos and the Tyranny: a Reappraisal of the Evidence* (Amsterdam 2000) 49–56.
- 5 S. Slings, ‘Literature in Athens, 566–510 BC’, in H. Sancisi-Weerdenburg (Ed.), *Peisistratos and the Tyranny: a Reappraisal of the Evidence* (Amsterdam 2000) 57–77.
- 6 H. van Wees, ‘“Those who Sail are to Receive a Wage”: Naval Warfare and Finance in Archaic Eretria’, in G. Fagan & M. Trundle (Eds.), *New Perspectives on Ancient Warfare* (Leiden and Boston 2010) 220.
- 7 Cf. the discussion in B. Lavelle, ‘The Peisistratids and the Mines of Thrace’, *GRBS* 33 (1992) 5–23. There is always the question of how Herodotos knew what he claimed to know.

Athenians under the Peisistratids of 5 % (Thuc. 6.54.5) or 10 % (*Ath. Pol.* 16.4 & 6). However, such taxation would surely have generated resentment whereas Thucydides mentioned it favourably ('exacting from the Athenians only a twentieth of their income'), and it would have required state apparatus to collect, which is unattested.⁸ It is possible Thucydides was confusing it with new revenue from mining and other sources (cf. discussion *infra*), and the *Ath. Pol.* story of the tax-free farm is apocryphal.

Coinage was probably adopted at Athens in the first decade of the third tyranny of Peisistratos, 546–ca.535.⁹ Despite the literary sources (Hdt. 1.64.1; *Ath. Pol.* 15.2) we cannot conclude that Thrace was the main external source of silver as testing to date has not established a reliable diagnostic guide,¹⁰ and at least for the earlier coinage issues it seems unlikely at first principles.¹¹ Access to Thracian silver was presumably lost ca. 512 when Darius conquered the region (Hdt. 5.11; 5.23). The Peisistratid tyranny was ended in 511/10, and the Athenian democracy commenced in 508/7.

At some period in the two decades 510–490, Attic coinage production was vastly expanded, and the main type changed from the *Wappenmünzen* to the 'owl'. Presumably these developments were related to exploitation of Laurion silver, but exactly when and why is uncertain, as is whether the changes belonged to the tyrants or the new democracy. The literary sources only tell us that the Athenians decided to use the proceeds of

- 8 K. Welwei, *Athen: vom neolithischen Siedlungsplatz zur archaischen Grosspolis* (Darmstadt 1992) 235. Pollux 8.130 claimed that a tax on a sliding scale was introduced by Solon, but G. de Ste Croix, *Athenian Democratic Origins and Other Essays*, edited by D. Harvey, R. Parker & P. Thonemann (Oxford 2004) 56–9 showed why this was very unlikely (cf. Rhodes *Commentary* [as in n. 3] 215). However, tax farming would impose minimal expense on the state as a Reader pointed out, and arguably Thucydides' testimony should be given more weight. Homeric leaders exacted contributions from the wider population (for instance *Od.* 13.14–15; *Od.* 19.196–8).
- 9 J. Kroll, 'From Wappenmünzen to Gorgoneia to Owls', *ANSMN* 26 (1981) 1–32. Prof. Kenneth Sheedy and I are currently compiling a comprehensive new corpus and die study of early Attic coinage down to 480/79 which we expect will shed more light on questions of dating. It is not impossible that the introduction of coinage could be down-dated to late in Peisistratos' tyranny, but the need for substantial payments especially for warfare provides a good reason for believing coinage was introduced by Peisistratos early in his third tyranny. Peisistratid imitation of Lydian/Ionian coinage would explain the brief use of electrum coinage, but this is a vexed issue, cf. G. Davis, 'Dating the Drachmas in Solon's Laws', *Historia* 61 (2012) 136–40.
- 10 The question of metal sources (including the large-scale testing of the composition of early-Attic coinage) is part of our current research. Existing analyses do not provide the certainty that many historians read into them.
- 11 The Gale hypothesis (N. Gale, W. Gentner & G. Wagner, 'Mineralogical and Geographical Silver Sources of Archaic Greek Coinage', in D. Metcalf & W. Oddy (Eds.), *Metallurgy in Numismatics*, Vol. 1 (London 1980) 3–49; restated in Stos-Gale, *Impact* [as in n. 1] 72–4) proposed that discrete sources of silver would have been used for early minting. At the 14th International Numismatic Conference held in Glasgow in 30 August–4 September 2008, I suggested that the substantial stocks of existing silver would have been used first and this must have been mixed and recycled. J. Kroll, 'The Monetary Use of Weighed Bullion in Archaic Greece', in W. Harris (Ed.), *The Monetary Systems of the Greeks and Romans* (Oxford 2008) 36, n. 74 independently made the same proposal arguing that minting was preceded by a period of trade and monetary use of bullion.

a rich silver strike at Maroneia in 483/2 to build the big fleet of warships which soon played an important role in defeating the Persian invasion under Xerxes and set the foundation for Empire.¹²

2. Exploitation of Laurion Silver

The Athenian mines were located in southern Attica in the district around the port of Laurion (modern Lavrio) after which Athenian silver is generally known.¹³ The deposits of silver-bearing minerals exposed through weathering on the side of hills (the so-called ‘first contact’) had been exploited since the Middle Helladic Period *ca.* late-sixteenth century.¹⁴ It is likely these were depleted by the sixth century, and the almost complete absence of silver finds in Attica dating to the sixth century suggests minimal activity.¹⁵ This is in contrast to Magna Graecia and the Near East where mixed hoards of sixth-century *Hacksilber* have been found.¹⁶ The bulk of the ore could only be exploited by underground mining of the much richer third contact, and it appears likely from numismatic evidence this did not occur on a substantial scale until late in the sixth century.¹⁷

Ardailon popularised the theory of the ‘contacts’,¹⁸ but oversimplified the geological reality especially with his implication that the second contact layer was sterile rock.¹⁹ Galena (plus sphalerite, pyrite etc.) was deposited from hydrothermal solutions that ascended through fractures in the limestone layers, but was trapped beneath weaker schists which were less permeable or had no fractures. Overpressuring led to brecciation (intense fracturing) of the more brittle limestones and resulted in deposition of metals in the form of sulphides from the solutions mostly in the limestones, with only minor sulphide precipitation in the schists. The brecciation event could result in some fracturing of the schist and upward leakage of mineralised solutions from the lowest layer (the third contact, which therefore had the best ore) to the layers above. The cross-sections of the deposits in Healy indicate that the second contact layer carried some low-grade

12 The sources are cited and discussed below.

13 It was not however the deme name. The derivation is presumably from *laura* (lane or passage) indicating the maze-like layout of the mines. The district was *Laurion* or *Laureion* with or without *oros* (mountain), or *Lauriotikē*, cf. A. Boeckh, *The Public Economy of Athens; to which is added a Dissertation on the Silver Mines of Laurion*, trans. G. Lewis, revised 2nd ed. (London 1842) 616 and n. 6 with references to the words’ ancient usages.

14 G. Daux, ‘Chroniques des fouilles 1966’, *BCH* 91 (1967) 628. Fragments of litharge were found in excavations at Thorikos.

15 M. Yu Treister, *The Role of Metals in Ancient Greek History* (Leiden 1996) 63.

16 Kroll, *Monetary Use* (as in n. 11) 24–35; C. Thompson, ‘Sealed Silver in Iron Age Cisjordan and the ‘Invention’ of Coinage’, *Oxford Journal of Archaeology* 22 (2003) 67–107.

17 Kroll, *Wappenmünzen* (as in n. 9).

18 E. Ardaillon, *Les mines du Laurion dans l’Antiquité* (Paris 1897) 13ff.

19 R. Hopper, ‘The Laurion Mines: a Reconsideration’, *BSA* 63 (1968) 299–300. I thank Dr Jim Ross, a geologist, who provided me with the explanation given in this paragraph in private communication.

mineralisation, albeit thin and discontinuous.²⁰ It may even have outcropped in valleys in a similar fashion to the first contact. Indirect signs of mineralisation extend beyond the ore itself, and it is easy to envisage how this would have encouraged exploration at deeper levels. The cross-section in Healy implies that exploitation of the second contact would almost certainly have led to the discovery of the richer third contact because on occasions the two contacts merge.²¹

The question arises why, if the existence of this enormously valuable commodity was known along with the technique of cupellation to extract it, silver was not mined more substantially earlier in the century. I suggest there were three main reasons:

- a. Economies of scale.** Extracting silver from silver-bearing lead ores (AgPb), mainly argentiferous galena (PbS), and cerussite (PbCO₃),²² was a very difficult and costly business. Discovery of the richer ores of the third contact would have stimulated investment. However, it needed to be on a large scale, because the investment had to be ‘paid for before any production’.²³ A typical ore had a total lead content of about 20%,²⁴ and a tonne of lead had approximately 2 kilos per tonne (0.2%) of silver,²⁵ so only about 0.04% of the ore was silver. The ore had to undergo many stages of finding, mining, dressing,²⁶ smelting, and cupelling before the purified silver was obtained,²⁷ together with some financially worthwhile by-products such as lead, copper, zinc, ochres, pigments and salves.²⁸ It required substantial resources of skilled and unskilled labour, infrastructure (housing, furnaces, washeries, cisterns), equipment, and imports from Attica and abroad (such as vast quantities of charcoal, hydraulic cements and plasters for the cisterns, iron for tools, bone and

20 J. Healy, *Mining and Metallurgy in the Greek and Roman World* (Plymouth 1978) 72–3.

21 Based on speleological examination of mines and shafts, D. Morin & A. Photiades, ‘Nouvelles recherches sur les mines antiques du Laurion (Grèce)’, *Pallas* 67 (2005) 327–58 proposed that the three contacts were created by geological folding of one contact. All contacts ought then to have similar concentrations of ore, but this seems not to have been the case. The validity of the theory does not substantially affect the arguments in this paper.

22 Lead carbonate or white lead. It forms from the oxidation of galena.

23 T. Rihll, ‘Making Money in Classical Athens’, in D. Mattingly & J. Salmon (Eds.), *Economies Beyond Agriculture in the Classical World* (London & New York 2001) 134.

24 C. Conophagos, *Le Laurium antique et la technique grecque de la production de l’argent* (Athens 1980) 127.

25 P. Christesen, ‘Economic Rationalism in Fourth-Century BCE Athens’, *G&R* 2nd series 50 (2003) 40; Rihll, *Making Money* (as in n. 23).

26 Itself a many-stage process, cf. Rihll, *Making Money* (as in n. 23) for a detailed account.

27 Purity is a function of refining. In a splendid example of empirical practice, T. Rihll & V. Tucker, ‘Practice Makes Perfect: Knowledge of Materials in Classical Athens’, in C. Tuplin & T. Rihll (Eds.), *Science and Mathematics in Ancient Greek Culture* (Oxford 2002) 278–9 noted that only when melted silver reaches 98% purity will it spirt, releasing the oxygen it has absorbed in solution, which provided a simple and foolproof sign for ancient refiners. In our testing of archaic silver coinages, most have approximately this purity, cf. D. Gore and G. Davis, ‘Suitability of Transportable EDXRF for the On-Site Assessment of Ancient Silver Coins and other Silver Artifacts’ (forthcoming).

28 Rihll, *Making Money* (as in n. 23); Rihll & Tucker, *Practice Makes Perfect* (as in n. 27).

marl ash for cupels, hides for bellows and containers, hemp for ropes and so forth) which had to be sourced, contracted, purchased, and transported. Suffice to say that mining at deep levels (the third contact at Camareza was 70–100 m below ground²⁹) was a major industrial process, though small-scale operators undoubtedly played a significant role in many (if not most) aspects of production.³⁰

- b. Technology.** This was responsible for making the mining industry viable late in the sixth century. The invention of the beneficiation workshops (*ergasteria*) which enriched ore and thus reduced smelting costs enabled the profitable processing of low grade ore.³¹ Little of the ore at Laurion was rich enough to economically smelt directly.³² There just happened to be a lot of it. Without the *ergasteria*, ‘none of the deposits poor in argentiferous lead were utilizable in practice’.³³ In addition, an obvious barrier was technological know-how. Mining and smelting relied upon practical experience, rather than theoretical or scientific understanding of chemistry and metallurgy.³⁴ However, the processes were complicated, multifactorial, and extremely dangerous.³⁵ A logical assumption is that when mining and processing commenced at Laurion in the second half of the sixth century, labour and expertise came, or were brought in from abroad, possibly from Thrace, given the name asso-

29 Conophagos, *Le Laurium antique* (as in n. 24) 161.

30 Not everything required large-scale investment or would have benefitted from economies of scale. A small stevedoring or refining business could set up with the same unit cost as a larger one, success being dependent on location, capacity and competitiveness, cf. P. Acton, *Manufacturing in Classical Athens* (forthcoming).

31 There is some dispute in the literature as to exactly what various terms meant, but the *ergasterion* was probably the ‘cistern/washing-table complex’, and smelting and cupellation took place at a *kaminos* (Hopper, *Laurion Mines* [as in. n. 19] 324). In the *poletai* documents, the operation of the two is ‘inextricably mixed’ (Hopper, *Laurion Mines* [as in. n. 19] 325; cf. Dem. 37.28). However, ore was crushed and broken at the *kenchreon* (M. Crosby, ‘The Leases of the Laureion Mines’, *Hesperia* 19 [1950] 195, n. 25).

32 Silver mined in ancient times only came from fields with higher mineral concentrations than can be productively mined today, but was inefficiently obtained. Strabo 9.1.23 (end 1st century BCE – early 1st century CE) noted that after silver mining had ceased at Laurion, there was sufficient silver in the slag to be worth reprocessing, and the reprocessed material was again reprocessed in modern times, starting in 1865 and continued by the Compagnie Française des Mines du Laurium to 1977 (Conophagos, *Le Laurium antique* [as in n. 24] 44–54).

33 E. Kakavoyannis, ‘The Silver Ore-Processing Workshops of the Lavrion Region’, *BSA* 96 (2001) 365.

34 Rihll & Tucker, *Practice Makes Perfect* (as in n. 27) 277–9.

35 Dangers included mining cave-ins and lack of ventilation, toxic fumes, and dealing with metals heated to ca. 810° C. Modern scholarship still has not convincingly solved the problem of how the early ancient mines were ventilated, as air from the surface quickly reaches a point in a shaft past which it cannot be easily forced to travel due to airway resistance unless it can exit another shaft (the early mines do not seem to have used these), and oxygen underground is soon exhausted by breathing and lamps. Cf. Morin & Photiades, *Nouvelles recherches* (as in n. 21).

ciation (Maroneia), or more likely Siphnos.³⁶ Maroneia was a *polis* on the coast of Thrace plausibly associated with mining since Homeric times,³⁷ but its importance was as a major *emporion* for Thracian slaves.³⁸ The depletion of the Siphnian mines may have led to the recruitment of skilled miners to Laurion.³⁹

- c. **Security.** This is one of the most significant but decidedly under-rated contributions of the Peisistratids to the development of Athens. Security was particularly important for mining as without it, no-one would sensibly make the large investments required. *Ath. Pol.* 16.7 makes mention that Peisistratos ‘safeguarded tranquility’. The fact that such a positive tradition would be recorded for the detested tyrants makes it credible. The essential role of the state in providing security for mining investment was also specifically stated by Xenophon (*Poroi* 4.43; 4.49; 5.1).

3. The Legal Basis of the State’s Silver-Mining Revenue

The current and long-held understanding is that the state ‘owned’ the silver under the soil of Attica.⁴⁰ This is the basis for the hypothesis that the state was entitled to a share of the revenues derived from mining. However, the evidence for the legal nature of this ownership and how it may have come into being is not solid and overdue for interrogation.

- 36 The possible Athenian benefit from Siphnian mining expertise was suggested by K. Sheedy in a presentation to the 13th International Numismatic Conference in Madrid, 2003, paper provisionally entitled ‘Athens and Siphnos: a relationship in silver mining’ (forthcoming).
- 37 There is a possible allusion to mining in *Od.* 9.196–211. It was a Thracian town settled by the Greeks in the middle of the sixth century by the Chians according to Ps-Scymnus 676ff (Müller, *GGM*), and was mentioned by the seventh-century poet Archilochos F2 (Diehl). For a fuller discussion cf. B. Isaac, *The Greek Settlements in Thrace until the Macedonian Conquest* (Leiden 1986) 114–7. Maroneia’s minting output back to the archaic period is given in F. de Callatay, ‘A Quantitative Survey of Hellenistic Coinages: Recent Achievements’, in H. Archibald, J. Davies, V. Gabrielsen (Eds.), *Making, Moving and Managing: the New World of Ancient Economies 323–31* (2005) 82–3 and Tables 4.4 & 4.6.
- 38 J. Young, ‘Studies in South Attica: the Salaminioi at Porthmos’, *Hesperia* 10 (1941) 182. He also noted that the hero Antisara found on the calendar of the Salaminioi has the same name as a port near Thracian Neapolis. Cf. Z. Archibald, *Ancient Economies of the Northern Aegean: Fifth to First Centuries BC* (forthcoming).
- 39 They include the wealthy family of Stesileides of Siphnos, resident in Athens in the fifth and fourth centuries as *isoteleis* and as mine lessees (J. Davies, *Athenian Propertied Families 600–300 BC* [Oxford 1971] 590ff s. v. C12 with *SEG* XXXIX and XLI 9 for new fifth-century evidence – I thank Prof. Davies for pointing this out to me; cf. Crosby, *Leases* [as in n. 31] nos. 5, line 2, and 20, lines 1–6).
- 40 M. Faraguna, ‘La città di Atene e l’amministrazione delle miniere del Laurion’, in E. Cantarella, J. Modrzejewski, & G. Thür (Eds.), *Symposion 2003: Vorträge zur griechischen und hellenistischen Rechtsgeschichte* (Vienna 2006) 141–59; G. Thür, ‘Antwort auf Michele Faraguna’, *ibid.* 161–5.

The proposition is often expressed using the German word – *Bergregal*, meaning state entitlement to ‘mining rights’ without ownership of the land under which the minerals were found.⁴¹ Although common nowadays, this concept is first securely attested in the Middle Ages in Germany, and was brought formally into law in 1158 CE by the Emperor Barbarossa as a revenue-raising measure. However, there is no definitive evidence that the Athenians had a legal concept of *Bergregal*. It relies upon deduction. Hopper, who was its influential advocate, posited a relationship ‘between the land and those who mined in it’ going back to the Bronze Age.⁴² This was necessary to accommodate the mistaken belief that substantial mining at Laurion associated with the development of coinage began at Athens in the late-seventh century, well before Peisistratos.⁴³ He firmly rejected private ownership of mines on the basis that there is ‘no evidence in specific cases for the purchase or sale of *metalla*’.⁴⁴ This required him to claim that verbs to do with purchase and sale (*prasis*) of mines actually meant ‘lease’ (*misthōsis*), and that the sense of the words was interchangeable, citing *Ath. Pol.* 47. 2 and 4.⁴⁵

There are a number of problems with this hypothesis:

1. It is primarily an argument *ex silentio*. In classical antiquity, mineral rights usually accompanied land ownership – this was the case in the Roman Empire for example.⁴⁶ At Athens, the state was substantially in the business of quarrying stone, but seems to have owned the Pentelic and Hymettian quarries.⁴⁷ There is no suggestion of *Bergregal* being extended to that activity or any other. Furthermore, no-one has convincingly explained the role, rights and revenue of the landowner over land rendered much less productive by mining.⁴⁸
2. There is no evidence for the Bronze Age connection, and yet (to the best of my knowledge) no other time or circumstances for the state acquisition of this lucrative right has been proposed. We might expect some notice in our sources from aggrieved landowners, or the citing of the relevant law. In fact, none of the extensive mining speeches ever explicitly says that the silver belonged to the state, even in a case where such an argument would be decisive (cf. especially Dem. 42). It is worth noting that legal procedures against mine owners were generally private matters as

41 This is a development from an earlier view that the state originally owned the mines absolutely and sold the rights to exploit them to miners in perpetuity for a fee (Boeckh, *Public Economy* [as in n. 13] 645).

42 Hopper, *Laurion Mines* (as in n. 19) 302.

43 Hopper, *Laurion Mines* (as in n. 19) 303.

44 R. Hopper, ‘The Attic Silver Mines in the Fourth Century B.C.’, *BSA* 48 (1953) 205.

45 Hopper, *Attic Silver Mines* (as in n. 44) 206.

46 Though salt was an exception.

47 M. Langdon, ‘Poletai Records’ in G. Lalonde, M. Langdon, & M. Walbank (Eds.), *Inscriptions: Horoi. Poletai Records. Leases of Public Lands (Agora XIX)*, (Princeton NJ 1991) 62 and n. 30; cf. R. Osborne, *Demos: the Discovery of Classical Attika* (Cambridge 1985) 105.

48 Cf. Osborne, *Demos* (as in n. 47) 118.

one would expect of private property, except for failure to register a mine which affected state income.⁴⁹

3. Some mines may actually have been owned by the state (cf. *ta dēmosia metalla* mentioned in *Lex. Cant.* 25.15–17; and the concession to Sokles in *IG II³ 433 = IG II² 411*).⁵⁰ Other examples make it clear the mine operator had physically bought something (cf. *Hyp. Eux.* 36 – *all' homōs hoi dikastai...ennōsan idion einai to metallon*) notwithstanding attempts to argue away the clear meaning of the passage – ‘still the jurors...decided that the mine was his own’. The Sausage-Seller in Aristophanes *Knights* 362 used the verb *ōneomai* (buy) to describe his proposal to purchase mines, and the *poletai* lists used *ōnētēs* for the ‘buyer’ of a mine. In *Ath. Pol.* 47.2 they (the state) sell (*polousi*) the rights to collect the income from the mines and taxes, while in *Ath. Pol.* 47.4 they rent public property (*tas misthōseis tōn temenōn*). It makes more sense to conclude with Lambert that when the operator was in possession, he was deemed to ‘own’ the product of the mine.⁵¹

The *Bergregal* hypothesis is plausible, but the onus of proof should fall on its advocates. In any case, I believe it is unnecessary. It is simpler to conceive the deal for exploitation of a mine being struck between the land owner and the mine operator. However, the state would have taken a strong interest in controlling mining operations (as ultimately reflected in the *poletai* lists – see discussion in the next section) to ensure they received their taxation and (at some point) registration fees,⁵² and to regulate the industry. Arguably it is this regulatory framework which has been mistaken for ownership.

Logically, both silver mining and taxation of mining were instigated by the Peisistratids.⁵³ They had the knowledge, motivation, authority, and resources to act. If, as

49 D. MacDowell, ‘Mining Cases in Athenian Law’, in E. Cantarella, J. Modrzejewski & G. Thür (Eds.), *Symposion 2003: Vorträge zur griechischen und hellenistischen Rechtsgeschichte* (Vienna 2006) 131.

50 The *Lexicon Rhetoricum Cantabrigiense* 25.15–17 defined *phasis* as the suit which ‘they bring against those digging under (*sic*) public mines and in general against those stealing public property’. ‘Cutting a mine inside the limits’ (whatever that meant, cf. discussion in MacDowell, *Mining Cases* [as in n. 49]) could be either a private or a public case depending on the ownership of the mine. For literature on reinterpreting the poorly preserved *IG II³ 433* as a *Prospektorenvertrag* see Thür, *Antwort* (as in n. 40) 162, n. 4, and doubts that it even concerned mining at all: Hopper, *Attic Silver Mines* (as in n. 44) 207–8; S. Lambert, ‘Athens, Sokles and the Exploitation of an Attic Resource (*IG II² 411*)’, reprinted in *Inscribed Athenian Laws and Decrees, 352/1–322/1 B. C.* (Leiden 2012) 363–76.

51 S. Lambert, *Rationes Centesimarum: Sales of Public Land in Lykourgan Athens* (Amsterdam (1997) 258).

52 V. Gabrielsen, ‘Finance and Taxes’, in H. Beck (Ed.), *A Companion to Ancient Greek Government*, (West Sussex 2012) 332–48 decisively demonstrated that *poleis* were quite willing to tax income contrary to common opinion based on M. Finley, *The Ancient Economy* (Berkeley / Los Angeles 1973, updated 1999) 164. The state taxed metics and trade in the ports of the *Arkhē* without owning them.

53 Conophagos, *Le Laurium antique* (as in n. 24) 94 suggested mining started slowly around 540 and accelerated down to 490. He noted that major mining would have been preceded by preparatory works

discussed earlier, they were instrumental at the outset in exploiting the silver mines and provided the secure physical and regulatory environment in which others could do the same, then they could reasonably have insisted on taking a percentage. After the Peisistratids fell, the democratic state took over their possessions, rights, and revenues.⁵⁴ This would have included mines directly owned by the Peisistratids,⁵⁵ and their rights to taxation together with the interventionary regulatory framework which ensured they received it.

4. Quantifying State Revenue from Silver Mining

Quantifying revenue to the state from the silver mines is difficult. It is made challenging by the fact that most of the evidence comes from the fourth century, and by doubt over the extent to which fourth-century practices and procedures can be retrojected to the fifth century. The main evidence can be easily summarised:

- a. A passage in the Suda (*s. v. agraphou metallou dike* α345 Adler = Phot. *Lex.* A255) records a law against unauthorised mining which notes *inter alia* that the state collected a tax on silver production of 1/24th. When this commenced is a matter of conjecture.⁵⁶
- b. In the middle of the fourth century, the state required money to be paid to it by mining entrepreneurs and recorded the sums paid on *stelai*.⁵⁷ The process is insecurely attested due to the fragmentary nature of the epigraphical remains and the uncertainties of the literary evidence, but it would appear that this was a system in which a

including reconnaissance, digging of pits and construction of surface installations, with equipment mostly procured from abroad. E. Raven, 'Problems of the Earliest Owls of Athens' in C. Kraay & G. Jenkins (Eds.), *Essays in Greek Coinage Presented to Stanley Robinson* (Oxford 1968) 58 made the point that the first issue of owls surely pre-dated 512 when the Thracian mines were lost to the Peisistratids owing to the Persian conquest, as it 'depended on a secure supply of bullion'.

54 Hdt. 6.121.2; L. Samons II, *Empire of the Owl: Athenian Imperial Finance*, *Historia Einzelschr.* 142 (Stuttgart 2000) 203–4.

55 U. Kahrstedt, *Staatsgebiet und Staatsangehörige in Athen: Studien zum öffentlichen Recht Athens* (Madison 1934) 26. P. Ure, *The Origin of Tyranny* (1922, repr. New York 1962) 33 ff went too far in suggesting that Pisistratos was a mine-owner and chief of a mass of contractors and miners.

56 G. Aperghis, 'A Reassessment of the Laurion Mining Lease Records', *BICS* 42 (1997/8) 9 made the interesting suggestion that it only applied to new mines translating *hoi ta argureia metalla ergazomenoi* as, 'Those who (already) operated a mine', but he concedes (p. 18) that there is 'no direct evidence of a silver tax other than the reference to a 1/24th'.

57 There is an extensive bibliography on the so-called 'mining leases'. See primarily: Crosby, *Leases* (as in n. 31); Hopper, *Attic Silver Mines* (as in n. 44); Osborne, *Demos* (as in n. 47); Langdon, *Poletai Records* (as in n. 47); Aperghis, *Reassessment* (as in n. 56); K. Shipton, 'The Prices of the Athenian Silver Mines', *ZPE* 120 (1998) 57–64; and C. Flament, *Une économie monétarisée: Athènes à l'époque classique (440–338)* (Louvain 2007). The first extant *poletai* records date to 367/6, and they continued until *ca.* 300 (though the last dated one is 307/6).

nominal sum was paid for initial exploration of a mine site for three years, followed by granting of the rights to a productive mine for either seven or ten years.⁵⁸ The documents are indicative of close control of the process. The overwhelming majority of the sums were small and constant, either 20 or 150 drachmas and all sums were divisible by five. Shipton (who pointed this out) is surely correct that they could not have been the result of competitive bidding at auction, and are better explained as a tax,⁵⁹ though I prefer to think of them as a mine registration fee. The state would have left individual entrepreneurs free to negotiate a price with the landowner. When this occurred, the mine's details together with the names of the parties and the amount payable to the state was recorded. There is no evidence as to whether this practice was followed before the fourth century, but some scholars assume it was.⁶⁰ Possibly it was introduced in the fourth century when mining started up again after the Peloponnesian War as a way of extracting additional revenue from mining in the face of declining yields.⁶¹

Most scholars believe that a tax of $1/24^{\text{th}}$ (= 4.17 %) could not possibly have been all the state received, pointing to the statement in Herodotos that the Siphnians divided the profit of their gold and silver mines among themselves (Hdt. 3.57.2). However, we have no way of knowing how the profit was calculated or its sum other than Herodotos' remark that the tithe (10 %) paid to Delphi 'was the equal to that of the wealthiest of treasuries' when the mines were at the height of production. Siphnian production was on a much smaller scale than that which developed at Athens (cf. n. 1); gold mining is vastly more valuable than silver mining; and any analogy to Athenian practice is purely conjectural. More tellingly, if the calculations by Conophagos are approximately correct that the peak average production in Athens in the fifth century was 20 tonnes per annum (736 talents),⁶² then the state would only have received approximately 30 talents p. a. from the $1/24^{\text{th}}$ tax. Samons sums up the general view: 'Such a fantastically low figure would provide insignificant revenues' to the state.⁶³

Literary evidence provides conflicting evidence as to how much revenue was collected from silver mining early in the fifth century. Herodotos 7.144.1 stated:

- 58 *Ath. Pol.* 47.2 – the text has $\Gamma = 3$ years, which is almost certainly a scribal error in the context. Emendations are $I = 10$ years (Kenyon, Oxford text 1920, accepted by Hopper, *Attic Silver Mines* [as in n. 44] 203), or $Z = 7$ years (Crosby, *Leases* [as in n. 31] 199–200; endorsed by Rhodes, *Commentary* [as in n. 3] 554 and more widely accepted).
- 59 Shipton, *Prices* (as in n. 57) 57: 'In the 74 complete prices which have survived 39 are 20dr. and 21 are 150dr.'. The amount related to the period and number of shafts being worked.
- 60 Langdon, *Poletai Records* (as in n. 47) 60–1; O. Picard, 'La découverte des gisements du Laurion et les débuts de la chouette', *RBN* 147 (2001) 5.
- 61 J. Kroll, 'On the Chronology of Third-Century BC Athenian Silver Coinage' (2013 forthcoming) suggests that given the reduced number of *poletai* mining concessions in the decades following their peak in the 340's, 'we have probably greatly overestimated the amount of Attic coinage minted over the second half of the 4th century from newly extracted silver'.
- 62 Conophagos, *Le Laurium antique* (as in n. 24) 138–52, 341–54.
- 63 Samons, *Empire of the Owl* (as in n. 54) 204, n. 153.

when the Athenians had a great amount of money coming to their public funds from the mines at Laurion, and proposed to distribute 10 drachmas a man to each of them; then Themistokles persuaded the Athenians to stop this distribution and to have 200 ships built from this money for the war...against the Aeginetans.

At 5.97.2 Herodotos stated that the Athenians numbered 30,000 citizens. Ten drachmas per person gives 300,000 drachmas – 50 talents,⁶⁴ and the clear implication is that this was an unusually large amount to be distributed. It is highly unlikely that 50 talents would have been sufficient to construct 200 ships (cf. n. 67), but the 10 drachmas per man distribution seems credible. We probably need to conclude that Themistokles was proposing the money go toward an ongoing ship-building program.

The picture is complicated by a version of the story in *Ath. Pol.* 22.7:

Two years later, in the arkhonship of Nikodemos [483/2], when the mines at Maroneia were discovered and the city gained 100 talents from working them, some advised that the silver should be distributed among the people, but Themistokles prevented this. ...he used it to get a fleet of 100 triremes built.⁶⁵

Rhodes found this credible noting that Athens had 70 ships in 489 (Hdt. 6.132, cf. 89) and 200 in 480 (Hdt. 8.1.1–2; 14.1).⁶⁶ If Athens had added 30 ships before 483/2, then 100 would make up the difference. This may well be correct, but it is more likely that Aristotle's figure of 100 talents rests on his assumption that a trireme cost a talent to build, and we may reasonably doubt that he had any way of knowing this.⁶⁷ It is difficult to harmonise the evidence,⁶⁸ but it is reasonable to conclude that the *Ath. Pol.* version of

64 Assuming the number of citizens is approximately correct.

65 Plutarch *Themistokles* 4.1, reinforced by Cornelius Nepos *Themistokles* 2.1–4, echoes the account in *Ath. Pol.*, though on unknown authority, that 'the Athenians were accustomed to share among themselves the revenues from the silver mines. ...He [Themistokles] alone dared to come before the people and say they should give up this distribution, and use the money to prepare triremes for the war against the Aeginetans'. Thus he neatly side-stepped the amount of silver but he quoted 100 as the number of triremes constructed, and added that he thought the distributions were an ongoing thing. Cornelius Nepos *Themistokles* 2.1–4 stated this even more explicitly: 'For since the public revenue coming in from the mines was lost each year in distributions by the magistrates, he persuaded the people that with the money a fleet of 100 ships should be built'. Polyainos *Strategems* 1.30.6–6 paraphrased *Ath. Pol.* without adding anything of significance.

66 Rhodes, *Commentary* (as in n. 3) 277–8. The Athenian contingent at Salamis was given as 180 by Aischylos *Persians* 342–3.

67 See discussion in S. Eddy, 'Four Hundred Sixty Talents Once More', *CPh* 63 (1968) 197 on the assumption, and V. Gabrielsen, *Financing the Athenian Fleet* (Baltimore & London 1994) 131–49 on the costs of triremes. G. Aperghis, 'Athenian Mines, Coins and Triremes', *Historia* 62 (2013) 13 argues the story was correct based on the (arguably anachronising) story in *Ath. Pol.* 22.7 of the 100 wealthiest citizens being lent a talent each to build a ship as a form of *eisphora*. Inflation was not well appreciated by Classical writers, cf. W. Loomis, *Wages, Welfare Costs and Inflation in Classical Athens* (Ann Arbor 1998), nor the effect of competition and scarcity on prices, cf. Dem. 17.28; Ps. Xen. *Ath. Pol.* 2.11–12.

68 As Gabrielsen, *Financing the Athenian Fleet* (as in n. 67) 29 pointed out.

a 100 talent windfall is not sufficiently strong to make a claim that it constituted annual state revenue from silver mining.

If progress is going to be made, a new approach is required. I propose to test approximately how much the state could have taken by examining the business of running a mine.⁶⁹ I am fully aware that all my figures are open to debate and criticism, and that the figures derive from the fourth century. The point is to provide an order of magnitude.

Table 1 provides a simple profit and loss statement for an ‘average’ mine.

Table 1: ‘Average’ mine profit and loss statement (before the state’s share)

Gross Income ⁷⁰	Silver and by-products (lead etc.)			12,000
Less expenses:	Rent			
	– land @8 % return ⁷¹	400		
	– slaves (rental/amortisation, food, clothing, lodging – 27 x 180 dr. p. a.) ⁷²	4,860		
	– foreman and security (purchase or hire, food, lodging)	600	5,860	
	<i>Kenchreon, ergasterion, kaminos</i> (ore grinding, washing, purification, smelting) ⁷³		1,260	
	Materials & transport (animals, carts, tools, lamps and oil, timber, rope, awnings; taking finished products to mint or market) ⁷⁴		600	

69 Aperghis, *Reassessment* (as in n. 56) 18–19 usefully started down this path. Calculations of some costs have been made by P. Gauthier, *Un commentaire historique des Poroi de Xénophon* (Geneva & Paris 1976) and C. Flament, ‘L’atelier athénien: réflexions sur la ‘politique monétaire d’Athènes à l’époque classique’, in Gh. Moucharté et al (Eds.) *Liber amicorum Tony Hackens* (Louvain-la-Neuve 2007) 4–5. I unashamedly employ a non-primitivist approach to Athenian economic practices.

70 Aperghis, *Reassessment* (as in n. 56) 18–19 – annual production of 6 million drachmas (based on Conophagos, *Le Laurium antique* [as in n. 24] 138–52, 341–54) divided by 500 known mines = 12,000 drachmas on average.

71 The owner of the property (*chōria* or more usually *edaphē*) in which the mine was situated was usually given in the *poletai* records (Crosby, *Leases* [as in n. 31] 194; cf. Dem. 26.2 and Isaios 11.42 for usage in literary texts). Osborne, *Demos* (as in n. 47) 57 and n. 41 noted the rate of return on land was usually 8%. However, the purchase price of mining land is unattested, so the figure given here is an educated guess. It should not be assumed that the sole return from land in mining areas was from silver mining (Hopper, *Laurion Mines* [as in n. 19] 310 and 322). There was agriculture – cf. the usage of the *peribolos* (enclosure, garden) to define some boundaries (*IG*² II–III. 1582. 65), pasturing, fuel, and, though it is generally overlooked, quantities of iron and copper ores.

72 Based on calculations of average number of slaves per mine, and costs per slave to hire, feed, and clothe in Aperghis, *Assessment* (as in n. 56) 18.

73 Taken from Dem. 37.4. The term *kaminos* is rare in the *poletai* documents and may ‘denote the installation where the more skilled operation of cupellation took place’ (Hopper, *Laurion Mines* [as in n. 19] 298). It seems to be part of the premises in Dem. 37.

74 This is a rough estimate as accuracy is impossible with our current knowledge.

	Finance – cost of borrowing @ 12 % ⁷⁵		570	
	Sundry			
	– mint fee @ 5 % ⁷⁶	600	1,210	9,500
	– amortisation of sunk costs + contingency ⁷⁷	610		
Net income				2,500

The figures are exceedingly rough and conservative estimates, but some things stand out clearly:

1. Even if a mine were successful as I have assumed here, the average profit margin to the entrepreneur was not large given the enormous up-front investment, labour, and risk. And the gain was uncertain – it lasted only as long as the silver did. Thus in Demosthenes 42.19 the speaker could say to a jury of his peers, ‘From my silver mines, Phainippos, I formerly by my own bodily toil and labour reaped a large profit. I confess it. But now I have lost all but a small portion of my gains’, partly ‘through having to share in the misfortunes common to all those who are engaged in mining works’ (Dem. 42.3). This point is reinforced by Osborne’s finding, based on an examination of the surviving *poletai* documents, that very few mining entrepreneurs (as opposed to owners of mining land) went on to exploit another mine or had family connections.⁷⁸ This led him to suggest that operating mines ‘was not the most profitable activity in the mining industry’. It is also important to note that the entire capital investment by the entrepreneur in a mine was a wasting asset which diminished to zero at the end of the term, which is presumably why they were not included in the assessment of assets for *antidosis* (Dem. 42.17–19), and have had to be amortised in my calculations.⁷⁹
2. The real winners were:
 - a. The slave owner – this is well attested in literary sources; Nikias is a famous example.⁸⁰ His wealth came primarily from leasing out slaves, which he did using an *epistatēs*, not from mining himself (Xen. *Poroi* 4.14 claimed he leased out 1,000 slaves at an obol each per day). It is notable that when Xenophon (*Po-*

75 Finance: $9,500 \times 12\% / 2$ (to average financing requirements across the year) = 570. Rate: deduced from Dem. 37.4 – the loan of 105 mnai to Panainetos on the security of a processing plant among the mine workings at Maroneia + 30 slaves at 105 dr. per calendar month, therefore 105 mnai = 10,500 dr; $105 \times 12 = 1,260 = 12\%$ interest.

76 See discussion *infra*.

77 Amortisation – see main text. Included despite the Finley school’s doubts that the concept existed – but they based this on literary writers’ texts, especially Xenophon’s *Poroi*, not real experience. A contingency must be factored in to any such budget allowing for unexpected costs (food, finance, delays etc). In addition there would be costs I am not aware of – bribes to officials, deme fees etc.

78 Osborne, *Demos* (as in n. 47) 115.

79 Cf. Hopper, *Attic Silver Mines* (as in n. 44) 205.

80 Davies, *APF* (as in n. 39) 403–7.

- roi* 4) made a proposal how the State might make more money from mining, his suggestion was to invest in slaves and lease them out to mining entrepreneurs.
- b. The land owner – it has been well demonstrated that these were usually members of the wealthy elite, though sometimes they also worked mines (or had them worked) under the land they owned.⁸¹ They frequently owned multiple mining properties presumably to spread the chance of reward.
 - c. The occasional miner who struck it lucky – the averaged figures hide the fact that a few mines would have been spectacularly successful, and given that much the same costs had to be paid irrespective of yield, a lucky strike would have brought a super profit – this would have been the lure.

It is reasonable to assume the state took seigniorage (revenue from the manufacture of coinage) which was *dokimon* (authorised) and therefore had to be under the state's exclusive control.⁸² This is supported by the story in [Arist.] *Oec.* 1354a 15–18 which demonstrates the state's ability to recall coinage for restriking at a profit. Arguably this was paid by the mining entrepreneur on the silver he produced, at a rate of 3 or 5%.⁸³ As Flament argued, the Laurion miners would have had to convert most of their bullion to pay their overheads, but his case that this was done by the state for free is unconvincing.⁸⁴ His suggestion that the bullion was melted at the *ergasteria* into flans (coin blanks) ready for striking on the spot or nearby is plausible, and if that is correct, it is where both the tax and seigniorage would have been collected.⁸⁵ However, the Athenian Coinage Decree, especially the Smyrna fragment, implies the mint was in the *astu* of Athens in the late 5th century, and there is no compelling reason to believe it was not there earlier in the century.⁸⁶ A fair proportion of silver used by the state had to be coined into frac-

81 Crosby, *Leases* (as in n. 31) 204; Osborne, *Demos* (as in n. 47) 117–24; cf. Davies, *APF* (as in n. 39) and J. Davies, *Wealth and the Power of Wealth in Classical Athens* (New York 1981).

82 P. van Alfen, 'Hatching Owls: Athenian Public Finance and the Regulation of Coin Production', in F. de Callatay (Ed.), *Quantifying Monetary Supplies in Greco-Roman Times* (Bari 2011) 135 & n. 1.

83 Known from the Athenian Coinage Decree. The percentage is unclear on the stone. Cf. J. Melville-Jones, *Testimonia Numoria: Greek and Latin Texts Concerning Ancient Greek Coinage, Volume 1: Texts and Translations* (London 1993) no.78; and J. Kroll, 'The Reminting of Athenian Silver Coinage, 353 B.C.', *Hesperia* 80 (2011) 229–59 for a detailed treatment.

84 Flament, *Une économie monétarisée* (as in n. 57) 247–9. He argued that it was to allow elites to pay for state obligations.

85 Flament, *Une économie monétarisée* (as in n. 57) 243. The State could accurately assess production at the *kaminoi*. 1/24th was easy to calculate as it equalled 1 obol in a tetradrachm.

86 I am not concerned here with the extensive debate over the the Athenian Coinage Decree and the composite nature of the text printed in IG I³ 1453. The location of the *argyrokopeion* in the fifth century is unknown but its existence is attested in the sources, cf. R. Wycherley, *The Athenian Agora, Volume III, Literary and Epigraphical Testimonia* (Princeton 1957) 160–1 and J. Camp and J. Kroll, 'The Agora Mint and Athenian Bronze Coinage', *Hesperia* 20 (2001) 127–62. The claim of P. Kalligas, 'A Bronze Die from Sounion', in K. Sheedy & C. Papageordianou-Banis (Eds.), *Numismatic Archaeology, Archaeological Numismatics: Proceedings of a Conference Held to Honour Dr. Mando Oeconomides in Athens, 1995* (Oxford 1997) 141–7 to have found a die at Sounion which would support Flament's argument is incorrect – the artifact cannot be a die for a *Wappenmünze*

tions (small denomination coins) suggesting this operation was separate from refining. The fees from each operation could have been extracted and paid at the site of each.⁸⁷

I now wish to examine how the state's share of the mining revenue would have affected the profitability of the mine. In Table 2 are alternatives that have been proposed ranging from 4.17 to 50 % (on the gross income and net income calculated in Table 1).

Table 2: The state's take on 12,000 gross income, and 2,500 net income (figures in drachmas)

Rate	Amount	Gross %	Net %	Miner's Profit/(Loss)	Miner's Share %
1/24 th – Suda s. v. <i>agraphou metallou dike</i>	500	4.17	19.7	2,000	16.7
1/24 th + mine registration fees ⁸⁸	930	7.75	36.6	1,570	13.1
10 % – Hopper and others ⁸⁹	1,200	10	47.2	1,300	10.8
20 % – Flament ⁹⁰	2,400	20	94.5	100	0.8
50 % – Thür ⁹¹	6,000	50	236.2	(3,500)	(29.2)

The figures permit the conclusion that a 1/24th tax was a realistic take by the state in addition to the minting fee because 4.17 % of the gross income equalled almost 20 % of the net; and it was easily calculated and extracted at the *ergasteria*. The larger percentages (20 % and above) would have rendered operations completely unviable and should be discarded. Even 10 % may have been too marginal for the risk compared with alternative forms of investment (bottomry loans for instance).

reverse on account of its shape which would yield the opposite result to an incuse. It is possibly a metal-working hammer, cf. K. Sheedy, 'The Sounion *Wappenmünzen* Die' forthcoming.

87 I thank Prof. Kroll for noting this to me in private correspondence.

88 No-one to my knowledge has previously suggested this even for the fourth century alone, but Boeckh, *Public Economy* (as in n. 13) 454–7 suggested an ongoing take of 1/24th plus the State's fee as a one-off payment.

89 Hopper, *Attic Silver Mines* (as in n. 44) 238 justified it solely as "a fair payment". Aperghis, *Reassessment* (as in n. 56) 18–19 argued similarly. Faraguna, *La città di Atene* (as in n. 40) 150, n. 35 joined the bandwagon. He cited Aperghis' 10 % but then added: "La mia impressione è, tuttavia, che il regime dovesse essere ben più gravoso per gli appaltatori".

90 Flament, *L'atelier athénien* (as in n. 69) 31.

91 Thür, *Antwort* (as in n. 40) 164–5 proposed a sophisticated arrangement whereby state officials calculated the yield and the State's share 'bei den Schmelzöfen' [at the furnace] of 50 %, based on the state being sovereign over silver production and effectively a silent partner in all mining ventures. 'So kann der Staat seinen Ertrag maximieren.' This is based on a restoration to *IG II² 411* (cf. n. 50) in which the state and a certain Sokles took the *karpōsis* each alternate year. If this had anything to do with mining, *karpōsis* must mean net profit in this context. As the figures demonstrate, 50 % of gross production would have been totally unviable to Sokles.

Is it reasonable after all to believe that the state's direct share of the fountain of silver in the early fifth century was 'only' on average *ca.* 50 talents per annum? I believe it is. It approximately equals the sum of the 4.17 % tax and 3 or 5 % minting fee.⁹² The argument that this was insufficient to build the fleet up to 200 ships is easily countered. Mining at Laurion went back into the sixth century,⁹³ and the Peisistratids had a key role in developing it. This forces the conclusion that the state had been collecting mining revenues for many years. Therefore the significance of the debate in 483/2 was the decision to apply the proceeds to the navy instead of distributing it. I note that Herodotus 7.144 specifically says, 'Themistokles had before this given another counsel that prevailed at this critical time [*es kairon ēristeuse*]', namely to use the proceeds from the silver mines for the state's purposes. Once the decision was made to spend the mining revenues on building ships, this continued in the subsequent years. Cumulative revenues of approximately 50 talents per annum would have been sufficient to build and maintain the fleet which fought the Persians.⁹⁴

The distribution in 483/2 may well have been exceptional, or not.⁹⁵ We simply do not know. But there are further indications that mining revenues did not have as large a direct benefit to the state as many scholars expect (with the notable exception of Hopper).⁹⁶ Perikles did not mention mining revenues in his famous speech *ca.* 430 summarising Athenian revenues in Thucydides 2.13. We can only assume they were part of what he referred to as 'other sources of income' in addition to tribute (2.13.3).⁹⁷ These

92 Based on Conophagos, *Le Laurium antique* (as in n. 24) 138–52, 341–54 who estimated the annual peak production in the fifth century at 20 tonnes (736 talents) per annum, but this would have fluctuated considerably. I am being deliberately conservative. Compare the 2 % Peiraieus harbour tax which yielded 30 talents, albeit in 402 very soon after the war (Andok. 1.133–4). Presumably it was considerably higher in better times. As discussed earlier, it is likely the two forms of taxes were separately collected, but I aggregate them here to reveal the state's direct take from silver production. Fees on the reminting of silver would have provided additional income.

93 Ardaillon, *Mines* (as in n. 18) 136 put the discovery of the third contact at Maroneia 'at the beginning of the fifth century' [my translation], but Picard, *Gisements du Laurion* (as in n. 60) 6–8 argued persuasively for a pre-500 date.

94 Cf. Diod. Sic. 11.43.3 dated (perhaps) to 477/6 (R. Develin, *Athenian Officials 684–321 BC*. [Cambridge 1989] 68), and the claim that Themistokles proposed a decree requiring the construction of 20 triremes (as replacements or additions?) to the fleet each year. Cf. J. Davies, 'Corridors, Cleruchies, Commodities, and Coins: the Pre-history of the Athenian Empire', *Byzas* 18 (2013) 48–58 (especially pp. 52–3) on the new funding demands of the 'trireme era'. Maintenance and operational expenses of the triremes once constructed are overlooked in many discussions. J. Morrison, J. Coates & N. Rankov, *The Athenian Trireme*, 2nd ed. (Oxford 2000) 199–200 estimated a 'life-span' 'as long as 20 years'. Cf. the 4th-century efforts to get trierarchs to return equipment to state-owned triremes (IG II² 1604ff).

95 The potential variability is indicated by the account of Thasian revenues varying from 200–300 talents p. a. (Hdt. 6.46.3). Assuming the Athenians were already mining the third contact, then the discovery of a high-grade seam would have given an almost immediate boost.

96 Hopper, *Laurion Mines* (as in n. 19) 304.

97 The point is reinforced by the scholiast's amplification, 'and from the produce of the earth, and from the convicts and the harbours and the mines and the rest'.

were summarised by Aristophanes in *Wasps* 658–9 as, ‘the taxes as well and the many one-percentages, the law-case deposits, mines, markets, harbours, fees and rents’ – so mining was not even at the top of the list in 422. Xenophon also failed to mention the state’s revenues from mining in his work *Poroï* despite his subject being how to increase state revenue from mining.⁹⁸

5. Effects of Mining on the Development of Athens

In addition to the direct revenue to the state from taxing mining and minting, there are a number of important ways in which mining affected the economic and political development of Athens:

1. Mining monetised the economy. The cumulative effect on the money supply must have been staggering. Seven hundred talents mined per annum would have yielded 4.2 million drachmas mostly minted into 1.05 million tetradrachms. These required 52 dies – a number broadly consistent with the evidence.⁹⁹ A considerable proportion of the coins would have been spent abroad purchasing materials, but over some years Athens must have been flooded with tetradrachms, transforming how money was used. Although the Athenians probably did not realise it, expenditure in capital-intensive activities such as mining, naval activity and building also would have had a ‘multiplier effect’.¹⁰⁰ This is where expenditure in one area requires further expenditure in another and so forth. The resulting cascade of spending boosts economic activity many times more than the original sum. It greatly increases overall demand in the economy and the money supply. This in turn would have further enriched the state itself through taxation.

98 I find it difficult to accept that the state gained an additional benefit by profiteering on the purchase of silver at a 10% discount as proposed by van Alfen, *Hatching Owls* (as in n. 82) 146. This is predicated upon the assumption developed from Rhodes, *Commentary* (as in n. 3) 553 that the mine-essor ‘was presumably free to dispose of the silver that he mined, the state’s mint being an obvious but not the only purchaser’. But if this were the case, why did the miners not sell the silver to other buyers at the full price? There was no shortage of external demand for silver.

99 Calculations given in T. Figueira, *The Power of Money: Coinage and Politics in the Athenian Empire* (Philadelphia 1998) 188. Based on the 20,000 coins per obverse die median figure established by F. de Callatay, ‘Quantifying Monetary Production in Greco-Roman Times: a General Frame’, in F. de Callatay (Ed.) *Quantifying Monetary Supplies in Greco-Roman Times* (Bari 2011) 7–29 (with a full list of references). A more conclusive answer to the question of the number of dies will soon come from the die study of Early Attic coinage which Prof. Kenneth Sheedy and I are currently undertaking.

100 Building, especially of temples: J. Davies, ‘Finance, Administration, and Realpolitik: the Case of Fourth-Century Delphi’, in M. Austin, J. Harris, & C. Smith (Eds.), *Modus Operandi. Essays in Honour of Geoffrey Rickman*, BICS Supplement 71 (London 1998) 1–14 and J. Davies, ‘Rebuilding a Temple: the Economic Effects of Piety’, in D. Mattingly & J. Salmon (Eds.), *Economies beyond Agriculture in the Classical World* (Oxford 2001) 209–229. Shipbuilding: Gabrielsen, *Financing the Athenian Fleet* (as in n. 67) Part III.

2. Mining involved substantial and ongoing capital investment. We have no direct evidence of investment in mining in the sixth century, but we can safely assume certain things: (a) such investment did occur and initially at least must have mostly come from wealthy members of the elite. It should be noted that lending was always an invisible (*aphanēs*) market even in fourth-century Athens, as were bank deposits and investments generally.¹⁰¹ Our lack of direct evidence of lending practice in the sixth century cannot be taken as an argument that it did not exist;¹⁰² (b) those involved in the business must have had (or developed) good trading connections both inside and outside of Attica; (c) a substantial proportion of those actively involved would have been from the south-eastern part of Attica where the mining occurred. In this respect, the local prominence of the Alkmeonidai, and their links with Delphi and Phokis and allied nobles is probably important;¹⁰³ (d) the scale of commerce involved with mining may also have helped drive the expansion of the navy to protect Athenian interests.
3. Mining required the development of sophisticated management and organisational skills. I have seen no discussion which has satisfactorily acknowledged the role and importance of management in this scale of enterprise, notwithstanding that Nikias was said to have spent the enormous sum of a talent on acquiring a slave with the requisite managerial skills (*Xen. Mem.* 2.5.2). The logistics were extraordinary. Virtually every item had to be sourced and brought in including equipment, supplies, food, charcoal and other raw materials required for processing, all of which required pre-planning, contracts, shipping and land transport. A huge and diverse workforce,¹⁰⁴ bigger than the population of most *poleis* at the time, had to be obtained,¹⁰⁵ housed, guarded, fed,

101 E. Cohen, 'The Athenian Economy', in R. Rosen, & J. Farrell (Eds.), *Nomodeiktēs: Greek Studies in Honor of Martin Ostwald* (Michigan 1993) 202–206.

102 Some confirmation can be found in the later make-up of investors, principally because they became the subject of dispute or notice in legal cases. K. Shipton, 'Money and the Élite in Classical Athens', in A. Meadows & K. Shipton (Eds.), *Money and its Uses in the Ancient Greek World*, (Oxford 2001) 129–44 demonstrated that 12–20 % of people who are known to have purchased mining leases which were visible because they were disclosed (*phanera*) in the fourth century were members of the liturgical class.

103 P. Bicknell, *Studies in Athenian Politics and Genealogy* (Weisbaden 1972) 1972: 40, 74 Appendix 3; G. Stanton, 'The Rural Demes and Athenian Politics', in W. Coulson, O. Palagia, T. Shear, H. Shapiro & F. Frost (Eds.), *The Archaeology of Athens and Attika under the Democracy*, (Oxbow 1994) 217–224 with fig. 2 at p. 219; J. Camp, II, 'Before Democracy: the Alkmaionidai and Peisistratidai', in W. Coulson *et al* (*ibid.*) 7–12. I am examining the question of the extent to which the Alkmeonidai controlled or were influential in the mining areas of SW Attica in a separate article, together with the question of the area designated by the term *paralia*, cf. Hdt. 5.81.3 and 1.59.3; Thuc. 2.55.1.

104 Rihll, *Making Money* (as in n. 23) 133 suggested a list of trades: 'basketmakers, potters, tanners, woodworkers, ropemakers, wheelwrights, hauliers, quarrymen, masons, bronzeworkers, ironmongers and engravers'.

105 Conophagos, *Le Laurium antique* (as in n. 24) 343–8 (summarised p. 348) calculated 11,000 workers were required to extract 20,000 kilos of silver per annum – his estimate of annual production in peak Classical times. Picard, *Gisements de Laurion* (as in n. 60) 5 claimed, 'notre économiste estime que la production d'une tonne d'argent nécessitait de 500 à 1.000 esclaves à l'année'.

ministered to, and organised into productive shifts. Buildings, *ergasteria*, cisterns, furnaces and so forth had to be constructed and maintained. Risk capital had to be raised and accounted for, and contracts entered into. Buyers had to be found for a large range of products including silver, but also lead, copper, zinc, ochre (used in vase painting, walls, sculpture and other decoration), pigments, ointments and salves.¹⁰⁶ The various products had to be packaged and safely transported. Many of these activities were subdivided specialties undertaken by different sets of individuals and groups, but even so they had to inter-relate and work effectively. I suggest that this new, jumbled, frenetic, non-agricultural environment was where many Athenians of all walks of life, especially in the far south of Attica, learnt to work cooperatively, and some obtained the skill-set required to help implement the Kleisthenic reform program.¹⁰⁷

6. Conclusions

Mining silver was literally mining money, but its exploitation was a function of geopolitics. No-one could do anything about the money sitting under their feet until certain things happened technically and politically to enable its extraction and sale. The right set of circumstances combined under the Peisistratids which contributed to their wealth and the prosperity of Athens. The democratic state took over the Peisistratid mines and, crucially, the right to tax the product of mines worked by others. However, it is not necessary to assume the state owned the silver beneath the ground in order to tax it. It is more logical to envisage a contractual relationship between the land owner and the mining entrepreneur albeit within a regulatory framework imposed by the state. The state insisted upon formal registration of mines recorded (at some point) by the *poletai* to ensure it received its proper share. It also benefited by taking a minting fee.

I have sought to demonstrate that the direct revenue from mining at the beginning of the fifth century was in the order of 50 talents per annum which is consistent with a reading of Herodotus' evidence. Although this is substantially less than most scholars have assumed, my rough calculation of the profitability of mining demonstrates that taxation above 10% gross would have made most mines unviable. However, the indirect benefits were astonishing. Arguably mining, and the huge liquidity it brought to the economy, was what made the difference between the paths of development of Athens and most other Greek *poleis* at the end of the sixth century. This has been too long under-appreciated in mainstream scholarship.¹⁰⁸ Money allowed Athens to build

106 Rihll, *Making Money* (as in n. 23) 135.

107 I explore the consequences of this in my thesis – G. Davis, *Law, Money, and the Transformation of Athens in the Sixth Century B.C.E.* (unpublished thesis 2011).

108 For instance, C. Reed, *Maritime Traders in the Ancient Greek World* (Cambridge UK 2003) in his excellent volume on maritime traders in the ancient Greek world which has a major concentration on Athens, did not even mention silver mining or its importance to trade. L. Samons II, 'Democracy, Empire, and the Search for the Athenian Character', *Arion* 8 (2001) 128–57 is one of the few to do so.

and man the most powerful fleet among the Greek states. Money and opportunity drew people and goods to Athens, boosting taxable trade and commerce. Mining, along with building and naval activity, transformed Athenian society through the development of sophisticated management and organisation skills among groups of Athenians. All these factors were interlocking and mutually reinforcing, and turbo-charged the development of Athens. They also meant that the old agriculturally-wealthy elite could no longer completely dominate politics and law. Now there were other players.

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