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The diachronic development of the Laurion mining landscape and its relation to process optimization in mining

ABSTRACT: *This article summarises the main results of my PhD thesis on silver mining in ancient Laurion. In the first part, the development of mining in Laurion is examined against the backdrop of the mining landscape model developed by Th. Stöllner. A correlation between mining activities and settlement development in the region is suggested. The second part discusses different theories concerning the main steps of the chaîne opératoire of silver production. It is argued that process optimization strategies can be detected in the ancient Athenian silver "industry".*

KEYWORDS: ATTICA, ANCIENT TECHNOLOGY, MINING LANDSCAPES, CHAÎNE OPÉRATOIRE

Introduction

In recent years, the reconstruction of the history and development of ancient mining landscapes has increasingly attracted scholarly attention (see e.g. Kassianidou and Knapp, 2005, pp.233–235; Bartels and Küpper-Eichas, 2008; Eisenach, et al., 2017; García-Pulido, et al., 2017, Nomicos, 2021; Hulek and Nomicos, 2022). In several articles, Th. Stöllner (2003; 2008; 2014) proposed a structured approach to the analysis of such "specialized region[s], whose primary economic structure is focused on the exploitation of (mineral) resources" (Stöllner, 2008, pp.76–77 fig. 4). These regions can be subdivided into *mining districts* (= a centre of production within the larger region) and even smaller *mining ensembles* which, for example, consists of a mine, a smithy and a smelting place (Stöllner, 2004, pp.429–430; 2008, 76–77 fig. 4). In mining landscapes, the development of human settlements can be closely interconnected with the mining activities (see Stöllner, 2003, pp.420. 433–435. 436).

The model is based on two columns: 1) Components of past mining economies that contributed to successful/unsuccessful mining operations and 2) the temporal development of mining landscapes. The factors that should be considered when analysing past mining landscapes are: the natural landscape, the cultural landscape, the mode of production, the social and cultural tradition, and trading modes and historical processes (Stöllner, 2008, pp.72–75 tab. 2). Concerning the temporal development of mining, Th. Stöllner differentiates between Phases of *extensive exploitation* (= sporadic, seasonal grasp of the resources) and phases of *intensive exploitation*. This second category, he subdivides into an *anterior phase*, an *initial phase*, a *consolidation phase* and an *industrial phase* (Stöllner, 2004, pp.430–439; 2008, pp.77–80). Based on the adaptive cycle model (Holling, Gunderson and Peterson, 2002), Stöllner suggests a final *phase of collapse* and *reorganization* (Stöllner, 2014, pp.138–140 fig. 7.3).

This methodological approach has not yet been applied to the Laurion. Despite serious destructions of the ancient remains by various activities since the 19th century AD, it is the widest studied and therefore best known pre-modern mining area (Fig. 1), and it provides a particularly suitable testing ground.

I begin by reviewing the development of mining at Laurion in the light of the different phases of the mining landscape model. This is followed by a brief examination of the decisive factors in this development. In the second part of the paper, I discuss to what degree process optimizing strategies can be detected in the ancient mining "industry".

The development of mining and habitation in ancient Laurion

At what time exactly the metal ores of Laurion were first exploited is still unclear. Possibly, the first resources to be exploited at Laurion were the hematite and ochre deposits for the production of pigments (see Rihll, 2001, pp.129–130; Nomicos, 2021, p.34). The earliest traces of underground pigment mining in Europe have been detected on the island of Thasos and dated to the Paleolothic (Koukouli-Chrysanthaki, Weisgerber, Gialoglou and Vavelidis, 1988, pp.241–242). Despite evidence for anthro-

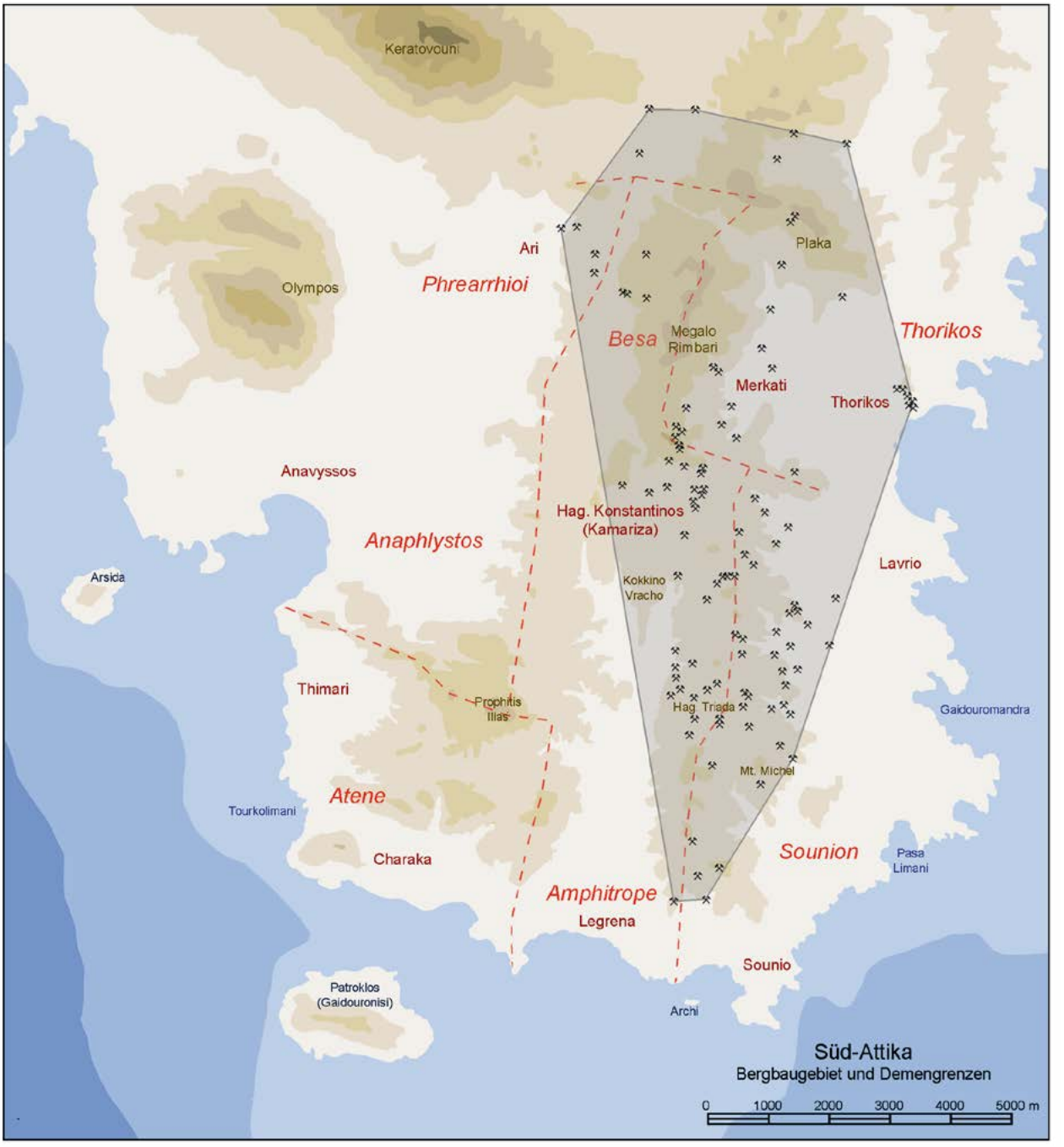

Fig. 1: Map of South-Attica with mining area and deme boundaries; scale ca. 1 : 100,000 (map by S. Nomicos, Ö. Özgül; distribution of mines after Konophagos, 1980, map; deme boundaries after Lohmann, 1993, p.109 fig. 12).

pogenic presence in Paleolithic Laurion ("Kitsos I", Lambert, 1981; Andrikou, 2020, pp.19–20) and the existence of ochre deposits (von Ernst, 1902, p.480), archaeological evidence for their exploitation at any period is missing.

The earliest evidence for metal mining at Laurion dates to the Late Neolithic/Early Bronze Age. There is indirect evidence in the form of cupellation residues from several sites in South Attica (Kakavogianni, Douni and Nezeri, 2008, pp.45–57; Kakavogianni, et al., 2009, pp.237–248; in this vol.; Georgakopoulou, et al., 2020). The earliest direct evidence from the Laurion are the traces of mining in Mine 3 that have been known for a while (Spitaels, 1984) and have recently been dated more securely to the Early Bronze Age II (Nazou, 2013; 2018; 2020; see also the comprehensive discussion in Kayafa, 2020). The litharge in a Middle Helladic stratum at Thorikos (Servais, 1967, p.23) is still the only evidence of mining activities in this period. Mycenean Laurion has been identified as a major silver supplier of the Aegean. This however is solely based on the indirect evidence of lead isotope studies (Stos-Gale and Gale, 1982). Despite the fact that (in view of the importance of Thorikos in the Mycenaean era see Laffineur, 2010; 2020;

Lohmann, 2005, pp.129–130; see also Papadimitriou and Cosmopoulos, 2020) this seems a very plausible theory, mining archaeological evidence to support these results is still lacking. Many questions concerning prehistoric mining in Laurion remain unclear; did mining take place only at Thorikos or were other deposits in the Laurion mined as well? Although several prehistoric sites in South-East Attica have been identified (see Salliora-Oikonomakou, 2004, pp.32–33; Oikonomakou, 2010; Papadimitriou, et al., 2020, pp.vi-xv nos. 77, 87, 90, 127, 172, 185, 196, 197, 198; Andrikou, 2020; Syrigou, 2020; Philippa-Touchais and Balitsari, 2020, pp.390–392), with the exception of the hillsite of Mokriza (see Lohmann, 1993, p.505, pl.72,1. 2 (AN 25); Parras, 2010, p.143, fig.4; Andrikou, 2020, p.22), their relation to mining activities remains hitherto unknown. Another unsolved question is the role of the Laurion as a copper deposit for the Bronze Age Aegean. Even today, copper minerals are known in the Laurion (Cordella, 1901, p.360; Kakavogiannis, 2005, p.92), but if and to what extent they were exploited is debated (see Nomicos, 2021, p.34 n.283). All in all, the evidence for prehistoric mining in Laurion is still scarce. It is in fact not even clear if the term “mining landscape/area” in the sense defined here can be applied to prehistoric Laurion.

Archaeological finds from geometric Laurion are scanty. The evidence for mining is inconclusive and there are hardly any signs for habitation from inland areas (see Nomicos, 2021, pp.77–79). Proof of settlement activity can be found at Thorikos (see Van Gelder, 2010), Anavysso (Kastriotis and Philadelpheus, 1911; Verdelis and Davaras, 1966, pp.97–98; Themelis, 1979, pp.108–109) and other coastal sites (see Nomicos, 2021, p.79). Despite the limited data, there might be an association between the lack of clear evidence for mining and the lack of geometric finds in the off-coast areas, which are not as favourable for human settlement. In terms of Th. Stöllner’s model, this period may be labelled as a period of *extensive mining*.

This situation changes noticeably during the archaic period (Nomicos, 2020; 2021, pp.80–88). Compared to the data available for the classical period, the evidence is still hard to interpret, but some basic observations can be made that attest for a beginning mining activities from the last third of the 6th century BC onwards. First of all, the literary testimony (Hdt. 7,144,1; Arist., *Ath. Pol.* 22,7; Aesch., Pers. 238) suggests increasing mining activities in the late archaic period the latest. This matches with the emergence of the Athenian owl coinage which according to the results of archaeometric studies (Kraay, 1958; Gentner, Müller and Wagner, 1978; Gale, Gentner and Wagner, 1980; Nicolet-Pierre, 1983) and literary evidence (Aristoph., Av. 1106) was made of Laurion silver. During this period, there is a gradual increase of sites in the inland area of the Laurion (Nomicos, 2020) while habitation in Thorikos intensifies (Mussche, 1998, p.62; Docter and Van Liefferinge, 2010, p.55; Bergemann, Klug and Docter, 2018). A connection between the mostly non-mining related archaic sites in the Laurion and intensified mining activities is supported by two observations: 1) the natural conditions – especially the lack of natural water – in the inland areas are most unfavourable for agrarian communities 2) some structures that were excavated, interpreted and discussed by E. Kakavogiannis (1989; 2001; 2005, pp.245–253) resemble the later ore washeries. Despite all the difficulties in their interpretation and dating (Kakavogiannis, 2001, p.369; Van Liefferinge, 2018, pp.539–540; Nomicos, 2021, p.84), they can, as suggested by E. Kakavogiannis, be understood as washeries of an early and maybe experimental stage when methods of exploitation of the ores in that arid and therefore precarious natural environment were tested.

This was mastered impressively as is attested for by the hundreds of large cisterns that can still be found all over the Laurion (see Konophagos, 1980, pp.252–254; Kakavogiannis, 2005, pp.225–229; Van Liefferinge, 2013; 2014; Nomicos, 2021, pp.59–61). As can be deduced from the contemporaneous literary evidence (Hdt. 7,144,1; Arist., *Ath. Pol.* 22,7; Aesch., Pers. 238; Thuk. 6,91,7) and the “almost unbelievable output” (Kroll, 2011, p.17) of Athenian coinage (see also Van Alfen, 2012, p.93), the 5th century saw a boom-phase in mining. This is not equally mirrored in the archaeological record which is dominated by finds dating to the 4th century BC. Nevertheless, there is some evidence to suggest that the main technologies of the Laurion industry (shaft mining, hydraulic mortar, ore washeries, and furnaces) were already developed and employed in the 5th century (see Nomicos, 2021, p.89–93).

After a hiatus of finds and other evidence from the first half of the 4th century, there is overwhelming archaeological evidence to suggest that the largest part of the now visible remains today dates to this period. This conclusion can be drawn from a meta-analysis (see Nomicos, 2021, chapter 3.4) of the results from numerous excavations and surveys. Together with the poletai records (see Crosby, 1941; 1950; 1957; Langdon, 1991) the picture of a densely worked and inhabited mining landscape emerges. This *mining landscape* comprised mines, workshops (Th. Stöllner’s *mining ensembles*), smelting furnaces, infrastructural remains, sanctuaries and burial places. There is reason to suggest that many of the at least 491 “sites” marked on the respective sheets of “Karten von Attica” date to this period (cf. Lohmann, this vol., pp.Seite 153–Seite 174). As the poletai inscriptions record, the 4th century mining landscape was organised in local sub-units, called *mining districts* by Stöllner, some of which can be located with some certainty (see Kalcyk, 1982a, pp.57–95; Lohmann, 1993, pp.89–110). What is unclear, however, is, whether the 4th century should be interpreted as *the* boom phase of mining in the Laurion or as a *second* boom phase. This is because the archaeological picture may be misleading. It is obvious that most of the evidence can be dated to this period. But is this because it really was the most intensive mining phase, or is it, because the area was abandoned around 300 BC and the remains of the 4th century were never "overprinted"? Did the 4th century then almost fully overprint the 5th century remains, and had they originally been equally dense? This at least can be suggested on the

grounds of the testimony of Xenophon who around 350 BC refers to a time in which "most people were involved in mining" (Xen., *Vect.* 4,3–4). This interpretation also finds some support in the archaeological record since 5th century BC pottery was found in a number of the excavated workshops (evidence compiled in Nomicos, 2021, pp.91–93).

Around 300 BC there is a sharp decline in settlement activity in Thorikos and the Laurion. Evidence for habitation can only be detected on some coastal sites. The mining industry clearly collapsed, as can be reasonably inferred from the fact that the workshops are abandoned around this time. Having said that, it may be discussed whether this was a sudden or gradual process. The latter seems possible, as some workshops have yielded 3rd century pottery, mostly plain ware (evidence compiled in Nomicos, 2021, p.108 n.1295). Since the internal chronology of plain ware is not always conclusive, conclusions must be drawn with caution. The reasons for the collapse of the mining industry were, for all we know, quite complex. There is clear evidence that "the mining yielded only meager returns" (Strab. 9,1,23; transl. H. L. Jones, 1924) towards the end of the 4th century. But it should not be overlooked that simultaneously Athenian minting activity came to an almost complete standstill, which will have resulted in a sharp decrease in the demand for silver (Nomicos, 2021, pp.108–110).

Renewed and reorganised activity in the Laurion can be detected in the 2nd century BC when older process residues were reprocessed (Lauffer, 1979, pp.165–166; Kalcyk, 1982a, pp.144–145; Lohmann, 1993, pp.245–246; Goette, 2000, p.106; Nomicos, 2021, pp.110–112) in what apparently were large-scale operations. Stamped amphora handles from several smelting sites in the Laurion attest archaeologically for this activity (Lohmann, 2005, p.126; Börker, 2018) that has been known for a long time from Strabo's account (Strab. 9,1,23) of these workings. The purpose of these operations may be found in the renewed Athenian minting activity (Lauffer, 1979, pp.165–166; Kalcyk, 1982a, pp.138–142; 1982b, p.246; Lohmann, 1993, pp.245–246; Börker, 2018, pp.70–72; Nomicos, 2021, pp.112–113; for the "New Style" Tetradrachms see Thompson, 1961; Mattingly, 1971; Boehringer, 1972; Mørkholm, 1984; Habicht, 1991) that correlates chronologically.

Strabo's account is somewhat ambiguous on the matter of whether or not the reprocessing of older residues continued in his own time. There is certainly no archaeological proof (compare also the literary sources Plut., *De def. or.* 43,5; Paus. 1,1,1) for any larger mineral processing or mining operations in the Laurion during the first four centuries of Roman Greece. Only a few sites have yielded evidence for small-scale lead production activities (evidence compiled in Nomicos, 2021, pp.118–119), although their dating remains difficult. In accordance with the account of Pomponius Mela 2,46, except for some smaller coastal sites (evidence compiled in Nomicos, 2021, pp.119–120) there are hardly any traces of habitation in the region.

The Early Byzantine period in the Laurion sees a remarkable increase in human activity even in off-coast areas, and the reprocessing of slags and other residues is intensified (Kakavogiannis, 2013). According to latest mining archaeological results by D. Morin (Morin and Delpech, 2018, pp.44–45), mining is taken up again during this period (see Nomicos, 2021, chapter 3.7). This matches the literary evidence (Paul. Sil. 678–681) and fits into the picture of the changing resource availability of the Byzantine Empire with the loss of the western half of the empire (Davies, 1935, p.251; Mussche, 1998, p.65; 2006, p.226; Docter, Monsieur and Van de Put, 2011, p.120; Nomicos, 2021, pp.124–125). This is remarkable, since it opens up a whole new set of questions to be addressed in the future. These concern not only the technical details of ore extraction but also the organisation of these undertakings. Around 600 AD however, the evidence for human activity in the Laurion declines sharply and remains low until the mining revival in the 19th century.

Discussion of the development of mining in the Laurion in the light of the mining landscape theory

South-East Attica was continuously inhabited with varying intensity from the Late Neolithic Period to Late Antiquity. Direct evidence for prehistoric mining of Laurion ores exists only at Thorikos, to what extent other parts of the Laurion were exploited remains unclear. In view of the lack of finds, only *extensive mining* operations in those parts seem likely, possibly only seasonally during humid parts of the year when water was available. With the emergence of the owl coinage, the first evidence of "workshops" and increasing settlement activity in the inland areas during the late Archaic period, an *initial phase* of mining can be detected. The impetus for this intensification will most probably have been the adoption of silver as base metal in the Greek world ca. 550 BC. A *radiation phase* can be postulated between the *initial phase* and the *industrial phase* during the 5th century, which is reconstructed mainly on the basis of the literary evidence. After a *phase of collapse* during the Peloponnesian War and *reorganisation* around the middle of the 4th century BC, a second *industrial phase* can be clearly detected in the material record. This is followed by another *collapse* by the around 300 BC. A *reorganised* industry with a focus on the reprocessing of older residues in the 2nd century BC can be reconstructed. Possibly in the 1st century BC the system *collapses* yet again. After a period of near standstill during the Roman Imperial Period, mining was resumed during the Early Byzantine Period. So far, the evidence is too scarce to allow for a comprehensive characterization of this phase. It can be observed however that there is another *collapse* around 600 AD that lasts until the 19th century.

The analysis of the settlement development in the Laurion shows that there is a traceable correlation with the mining history, and a causal relationship is suggested (see Nomicos, 2021). This can be deduced, on the one hand, from the changing quantity of finds and, on the other hand, from the fact that in intensive mining phases both the coastal region and the inland areas show traces of settlement, whereas in phases with little or no mining activity the sites are limited to the coastal region. Therefore, mining directly affected the settlement development of the Laurion.

Several factors can be identified that directly influenced the productivity of the mining industry in the Laurion. These comprise especially *the quality and accessibility of the deposit* and the *supply and demand structure*. The former is one way to explain the absence of extensive mining activities in the Laurion outside of Thorikos before the late archaic period. The mining of the inland deposits only really took off, when firstly the so-called third contact, the rich and ca. 100 m deep (Kakavogiannis, 2005, p.92) deposits, could be reached by means of sinking of deep shafts and secondly, when the water-management problem was solved by the construction of countless large cisterns plastered with the distinct hydraulic mortar which made the mining industry independent from seasonal water availability. Only then could the lead-silver ores be effectively and perennially processed in the numerous washing tables, which were also lined with hydraulic mortar. The success of Athenian mining therefore was the result of (and only made possible by) these three technological innovations: deep shafts, large cisterns, and water-proof mortar. Unfortunately, we do not know any details on how these inventions were developed and who was involved. We can only guess that the Laurion attracted "mining engineers" from other regions such as Thrace and Siphnos who contributed to the technological innovations (Kalcyk, 1982a, p.109). The latter factor is not only manifested in Athenian coin production, but later in the Byzantine Empire also, according to Paul the Silentiary, in silver for decorative purposes. The *changing supply and demand structure* was moreover greatly responsible for the standstill in mining in the second half of the 5th and first half of the 4th century which is to be explained by the events and the aftermath of the Peloponnesian War.

The role of process optimization in reconstructing ancient technical processes

With regard to the Laurion, the one component of past mining economies that has attracted much scholarly attention is that of the *mode of production*. Reconstructing the chaîne opératoire of ancient Athenian mining was the aim pursued already by A. Kordellas (Cordella, 1869) and E. Ardaillon (1897). It was the seminal work by K. Konophagos (1980), however, that systematically considered the different steps of the technological process comprehensively. Being a mining engineer himself, much insight was gained by his process-optimising approach. Yet, some of his theories have been questioned, especially by archaeologists (Trikkalinos, 1978; Kakavogiannis, 2005, p.241; Lohmann, 2005, pp.113–116). How does this change of perspective help to reconstruct the process chain and to what extent can process optimisation measures be detected in the classical silver "industry"?

The process of silver production in classical Laurion, after prospecting, started underground. The ore was extracted from subterranean chambers which were reached by narrow passages branching off deep shafts. Already A. Kordellas (Cordella, 1869, pp.82–86) noted that different types of shafts existed, but it was Konophagos (1980, pp.197–206) who described them in more detail and distinguished seven different types (Konophagos, 1980, p.188 fig. 9–32). He explained the differences with alternative ways of accessing ("riding", see Weisgerber, 2005 p.40) the deposits. The examination of the shafts conducted by D. Morin (Morin, Herbach and Rosenthal, 2012; Morin and Photiades, 2012, Morin, in this vol.), however, suggests that the main difference between the shaft types lies in their ventilation techniques. Important new results are to be expected from the current project by M. Vaxevanopoulos (see Vaxevanopoulos, in this vol.).

The topic most widely discussed by engineers, archaeologists and mineralogists alike is ore beneficiation (see Nomicos, 2021, chapter 2.2). Before the ore can be extracted by metallurgical processes, it must be first reduced in size and then separated from the gangue. Different methods of size reduction can be reconstructed in the Laurion. The most ancient method of size reduction of all materials is that of pounding. Such bedrock processing floors are known from all over the world (see for example: Craddock, 1995, pp.159–160 fig. 5. 3–5. 4; Eitam, 2009; Fig. 2), but they had not been described for the Laurion until 2015, when, during the Survey at Ari several such sites were discovered (one of them additionally comprising bedrock mortars, see Lohmann, this vol., p.161 Fig. 7). Unfortunately, the dating of these features is elusive because they constitute a universal method not restricted to one area or time period. Size reduction was furthermore achieved by grinding the ore either in saddle quern-like devices or hopper querns (compare Lohmann, this vol.). The structures known as "helicoidal washeries", first observed by Young (1942, p.95 in the footnote) but thoroughly described and reconstructed by Konophagos, can in view of previously unknown in-situ finds be more consistently reconstructed as mills of the kollergang type; there are however contrasting views on their dating and purpose (Nomicos; 2013; 2017; Papadimitriou, 2015; 2016; 2017). A recent find at Ari is interpreted as a part of a stamp mill (see Nomicos, 2021, p.57–58 pl. 18,1; Lohmann, this vol.), which could be the earliest evidence of this technology.

Fig. 2: Depiction of stone pounding (after Lynch und Rowland, 2005, p.31 fig. 3.7 (b); digital post-processing L. Hecht).

A much-disputed question (Negris, 1881; Konophagos, 1980; pp.223–224, 241–246; Kakavogiannis, 1992; Domergue, 1998) is the exact function of the famous ore-washeries, of which hundreds have been preserved in the Laurion. There are arguments in favour of the reconstruction put forward by Ph. Negris (1881; see also Agricola, 1556, p.261 with fig.) in the 19th century with an adjustment concerning the purpose of the basins. In accordance with the results presented by E. Photos-Jones (Photos-Jones and Jones, 1994), these may be understood as means of classification (Nomicos, 2021, pp.67–68).

Hardly understood are the smelting, cupellation and lead production techniques employed in ancient Laurion, although different reconstructions have been put forward (Wilsdorf, 1974, p.1758; Konophagos; 1980, p.289 fig. 11–1; Papadimitriou, 1995, p.255 fig. 3; Kakavogiannis, 2005, Pl. 18; for a discussion see Nomicos, 2021, pp.69–71). Interpreting the material remains from these processes is particularly difficult because of a general lack of archaeological contextualisation. A blind spot of the process chain is the cupellation method employed in ancient Laurion. Although several types of litharge (plate-shaped and tubular), the by-product of cupellation, have been found in great numbers (see Konophagos, 1980, pp.307–326; Kakavogiannis, 2005, pp.273–281 with pl. 23; see also Papadimitriou, 1995; 2012; for a discussion see Nomicos, 2021, pp.73–74), the actual furnaces have not survived. Due to the Laurion's complex mining history, it is hardly possible to contextualise these remnants reliably.

The change of perspective from an engineering to an archaeological/historical point of view leads to different interpretations of the material remains all along the process chain. This is demonstrated by the new interpretation of the different shaft types in the Laurion by D. Morin. It also becomes apparent, when analysing the different means of size reduction. The stone blocks interpreted by Konophagos as pounding tables can in the light of typological parallels be better explained as saddle quern-like mills and the "helicoidal washeries" as kollergang-type mills. Moreover, the material remains of the washeries lack any indication of the sluices proposed by Konophagos and can more consistently be reconstructed in another way.

That being said, the theory of process optimization as implicitly employed by K. Konophagos merits careful consideration. Especially when stratified contexts are missing – as is the case in the Laurion – it proves to be an invaluable tool in explaining the use of different archaeological finds which belong to the same process step but differ in their technical efficacy. The way in which Konophagos repeatedly employed this notion was to reconstruct a several step process: according to him, 1) the ore was first reduced in size coarsely on the stone

blocks here addressed as saddle quern-like mills and the finely ground in the hopper querns (Konophagos, 1980, pp.219–223); 2) the metal was first handled in a way that produced the plated litharge and then in a way that produced the tubular type (Konophagos, 1980, p.308). These conclusions are consequential when considering all the remains as belonging to the classical period. Since we know today however that the mining history of Laurion was much more complex with different modes of production and uses of the deposit, this one-dimensional view has to be challenged. It can be argued, for example, that the different milling devices represent different steps in a long-term technological development. In this hypothetical scenario the hopper quern could be a technological innovation (of the 4th? century BC) superseding the earlier (?5th century BC) saddle quern. The kollergang-type mills and the newly discovered stamp mill may be understood as even further steps of this mechanization process of size reduction.

Conclusions

Silver mining in ancient Laurion has been the subject of scholarly attention for more than two hundred years. Owing to the results of numerous excavations of the past decades, it has only recently become possible to draw a more differentiated picture of the diachronic development of raw material exploitation. Employing the mining landscape model developed by Th. Stöllner allows for a structured approach in reconstructing different phases of exploitation that furthermore takes into account the various factors of rentability. The discussion of the connection between the settlement and the mining history revealed a close correlation and causal relationship between the two.

The example of Laurion shows moreover that the theory of process optimisation, as implicitly employed by K. Konophagos, helps to better explain ancient Greek technological processes when typological parallels, results of archaeometric analyses, and historical processes are carefully considered. This conclusion is significant because, when employed systematically, it adds a new perspective to the study of technology in ancient cultures in general and technological innovations in particular.

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