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Ancient Laurion: Stages, phases and landscape

ABSTRACT: *Where do we stand 160 years after the first systematic exploration of the Laurion district? This paper attempts to assess the overall picture of our progress in solving the great puzzle presented by the main distinctive characteristic of the Laurion Peninsula: its very large scale. It sets off by pinpointing the main pending questions linked to the interpretation of the area's material culture and its landscape; it proceeds to organize them in an intra-referenced sequence of stages and phases. Materials and structures related to mining and metallurgical technology are targeted. For example: how did the ore washeries evolve, how did this evolution participate in structuring the landscape? How did human collectivities co-evolve as to their internal structure? How was this reflected on changes in their landscape organization principles? The major problems of chronology are tackled by sequencing each class of material evidence (katharistêria, hydraulic technology, mining galleries and shafts)[1], independently, based on purely archaeological data. A seven-phase scheme is proposed and compared with established historiographic sequences for a Laurion relative chronology to emerge. The whole network of identifiable evolution lines is proposed to be understandable within a large-scale landscape perspective and this is exemplified in the case of a suggested triggering of urbanization processes within the Athenian Chora. These large-scale dynamics are made visible in structuring power relations which control land (surface and underground), water and human labour.*

KEYWORDS: ATHENS, LAURION, ANCIENT MINING, ANCIENT METALLURGY, SETTLEMENT PATTERN, LANDSCAPE ARCHAEOLOGY, CLASSICAL ARCHAEOLOGY, CHRONOLOGY.

Introduction

It has been almost 160 years since the first systematic exploration of the Laurion district (for place names cited in the text see Fig. 20)[1] as to its link to the material and social dimensions of an emblematic ancient political society, i.e. the Athenian Polis (Cordella,1869; Négris, 1881; Ardaillon, 1897). And almost 2,500 years since the writing of the first known socio-economic analysis on the same region (Xen., Poroi, 4). How have we progressed to date? Even though an impressive amount of work has been done, it seems that essential questions, originally set, remain unanswered.

An overview of such questions inevitably has to address the evolution of ore-processing related structures typologies and their chronologies, the understanding of the entire chaîne opératoire involved, as well as the decoding of the topography of the Laurion Demes and its spatial organisation throughout antiquity.

Persistent questions and yet an overwhelming corpus of data. The comprehensive understanding of Laurion has fallen victim to its unusually large scale: multidisciplinary research remains dispersed and in need for a constant, in-depth dialogue and cooperation between disciplines. There is the necessity to collectively focus on describing and trying to resolve problems and questions that will allow us to achieve an understanding and a synthesis at this large scale.

Methodological framework

The present contribution embarks onto an effort to establish a comprehensive relational phasing scheme for ancient Laurion, setting off from problems in our current state of research, with dating considered as an axial issue. In the present occasion, prehistoric and protohistoric periods are not dealt with and a background knowledge for the following periods is considered as known. This is a five-fold effort:

1. The phasing scheme is aimed to be structured independently, based on purely archaeological data, interweaving evolution sequences, which correspond to discrete practices (mining/ore processing/water management), all tightly linked together within the Laurion mining-metallurgy *chaîne opératoire*.
2. By sequencing each class of material evidence considered (e.g. *katharistêria*[2], hydraulic technology, mining galleries and shafts[3]), their evolution is structured

Fig. 1: Distribution of stage K–1 FBW (Google Earth with additions by A. Kapetanios).

in stages. Synchronisation between stages is then attempted, which produces a seven-phases scheme.

3. In parallel, as archaeological data is compiled and organised in the above manner, important pending questions are highlighted, and suggestions are made on planning further research.
4. The scheme is then juxtaposed to the established historiographic/epigraphic sequences and the result of their superimposition is discussed.
5. Besides its self-evident significance in sequencing archaeological material assemblages, the proposed scheme is applied here heuristically to unravel principles structuring ancient communities in the Laurion peninsula landscape, outlining what I consider the Laurion landscape dynamics. Scale issues prove to be crucial in developing such an understanding.

Problems of chronology

One of our main problems, as regards the bulk of Laurion material remains, which densely cover 25 km² of its valleys, is chronology. This is due to a spectrum of both taphonomic and operational factors:

As to taphonomy, datable archaeological finds rarely derive from undisturbed fillings; the architectural remains of the *ergastêria* have been visible on the land-surface for thousands of years and were intensively exploited in the second half of the 19th century for metallurgical remains employing heavy industrial machinery. Furthermore, these finds are related to the use of the installations and thus provide *terminus ante quos*. To date, we lack direct and safe dates for the construction of mining works and ore processing installations. In the rare occasions that foundation trenches were identified and systematically excavated, as in the trial excavation at Ary 63 in the framework of the Ary project (Lohmann, 2020; Hulek, this vol.), no datable material has been retrieved so far.

Taphonomy is also relevant in the case of surface finds. The pre-eminence of the 4th century pottery is often referred to as conspicuous on the surface of the workshop valleys. This is certainly an important observation, but still an impression rather than the product of a systematic survey, with the exception of those undertaken at Ary (as in the Ary project, Lohmann and Kapetanios in prep.) and at Thorikos (van den Eijnde, et al., 2018). Taphonomic factors should be assessed before such a general picture becomes an argument. For example, the industrial character of the installations involves coarse pottery of long-lived types, such as the lekanai. Lekanai rims, besides being easily recognisable, are exceptionally strong and resist breaking into small fragments. There is thus a strong recovery bias in favour of lekanai, which, even in the light of G. Lüdorf's (2000) seriation, can hardly provide the chronological resolution needed.

These being said, the results of the extensive and partly intensive Ary survey draw an interesting outline, even though the assemblage of datable surface pottery is rather small: there is a peak at Classical times (80 %), with 4th century clearly recognizable; the next peak, though very much lower (5,5 %), falls into the Late Roman/Early Christian period; Hellenistic sherds come third and last with a very low representation (1 %) (Lohmann, 2020; Lohmann and Kapetanios, in prep.).

Fig. 2a: K–1 FBW, Haghia Triadha, Souriza (photo A. Kapetanios).

A way to answer the above mentioned methodological problems is to carefully plan a combination of systematic, extensive and sampling-intensive surveys, which will allow statistical assessment of surface pottery in the Laurion valleys.

As to operational factors, the majority of the cases of archaeological investigation at *ergastêria* have been conducted in the context of salvage excavations. Their priority has been to identify ancient material remains and thus to protect them from destruction in the context of modern developing works. The massiveness of the surviving installations, their state of preservation and the intrinsically urgent character of the investigation have scarcely allowed for trial excavation beneath them.

Besides, we lack detailed published data on pottery deriving from well documented *ergastêria* contexts related to stratigraphy, which could contribute immensely, unraveling issues of chronology.

On the one hand, salvage excavations results have been published only preliminarily in reports[4] their pottery assemblages awaiting thorough study and publication. In the reports, the excavators give an overview of the pottery chronology in order to date the structures. In the case of two *ergastêria* excavated within the Thorikos valley complex, their pottery is summarily described (Salliora-Oikonomakou,1997a) assigning their foundation and use to the 2nd half of the 4th / first half of the 3rd centuries BC, and a revisit, to exploit metallurgical by-products, to Late Roman times.

It is imperative, then, that a wide collaborative project, focusing on the study and publication of contextualised pottery from the numerous *ergastêria* salvage excavations should be initiated.

On the other hand, similar issues are not absent in systematic investigations. Indicatively, the pottery assemblages deriving from the systematic excavations carried out by the late K. Tsaïmou at Ary I, II, III (Τσάϊμου 2006, 2008; Τσάιμου and Τσάιμου 2010) have just been presented by Nomicos and Tsaïmou (in prep.) and should contribute decisively towards a sound documentation of these very important installations as to their chronology. The other systematic excavation on the South slope of Mihales hill, focused more on metallurgy and, apart from an overall dating of the pottery to the 4th century BC, it provided few data on datable pottery in context, which remains unpublished (Jones, 2007, p.275; Photos-Jones and Jones, 1994) and therefore urgently needs to be revisited and studied. The Thorikos Project's (Docter and Webster, 2018) systematic excavations and survey reports, spanning over more than four decades, are the standard source for pottery data, even if preliminarily. Research at Ary II, i.e,. an ergastêrion with circular mill (formerly helicoid washery – see below), a type I "flatbed washery" (hereafter, FBW) and a row of smelting furnaces (*káminoi*), provided the only, so far, absolute dating for archaeo-metallurgical materials but with low chronological resolution: radiocarbon dating of litharge slags retrieved from the *káminoi* gives low resolution calibrated dates

Fig. 2b: K–1 FBW beneath a tower from the 4th century BC, Souriza Valley (photo, information leaflet for the archaeological site, Ephorate of Antiquities in East Attica)

for two samples, falling with a certainty of 95,4% within 203–46 BC and 198–47 BC respectively (Tsaïmou, et al., 2015, p.118, tab.1). If taphonomy is straightforward, these dates probably refer to the module's latest operating years.

In the face of lacking reliable and numerically sufficient direct archaeological chronologies, indirect dating based on historiography[5] was used to provide the canvas for developing synchronies. This is examined further below.

Relational sequencing

In this section, we may try to compensate the scarcity of meaningful relative or absolute dating by systematising our current knowledge within relational sequencing instead of calendric dating, as prescribed above.

Katharistéria

The evolution of silver extraction technology in Laurion, can lay the warp to weaving such a phasing, starting with the relational arrangement of technological attributes and features of the *katharistérion*, the main structure of the ore cleaning (to enrichment) *ergastêria*, known as "flatbed washery" (FBW Παπαδημητρίου,1992; Kakavogiannis, 2001).

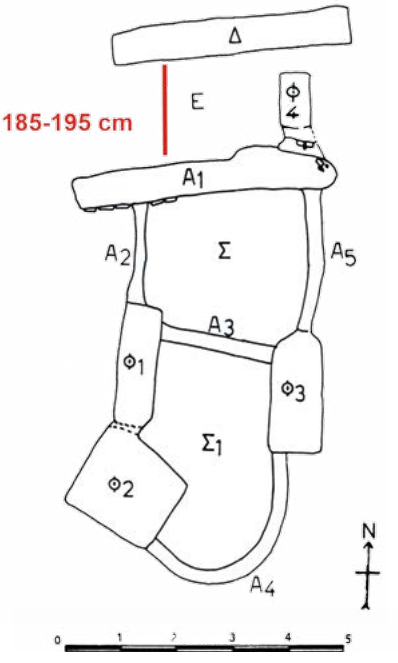

Fig. 3: Layout of a K–1 FBW at Bertseko valley (after Kakavogiannis 2001, with additions by A. Kapetanios).

Stage 1

There is certainly an early stage in the evolution of the FBW, prior to the vast majority of standardised *katharistéria* spread all over the Laureotike peninsula (Figs. 1, 2a, 3).[6] Besides the purely formal attributes assigned to the early type, characterising it as experimental and thus irregular (Kakavogiannis, 1989; 1991, p.369), there is direct relational evidence in the case of one such *katharistérion* excavated by E. Kakavogiannis beneath a definitely classical-late classical tower in the Souriza complex (Fig. 2b).

However, datable material related to these early structures is poor (Kakavogiannis, 2001, p.369) and certainly not linked to their construction phase. Consequently, we can only refer to them as early, or stage 1, *katharistéria*, rather than pre-classical ones.

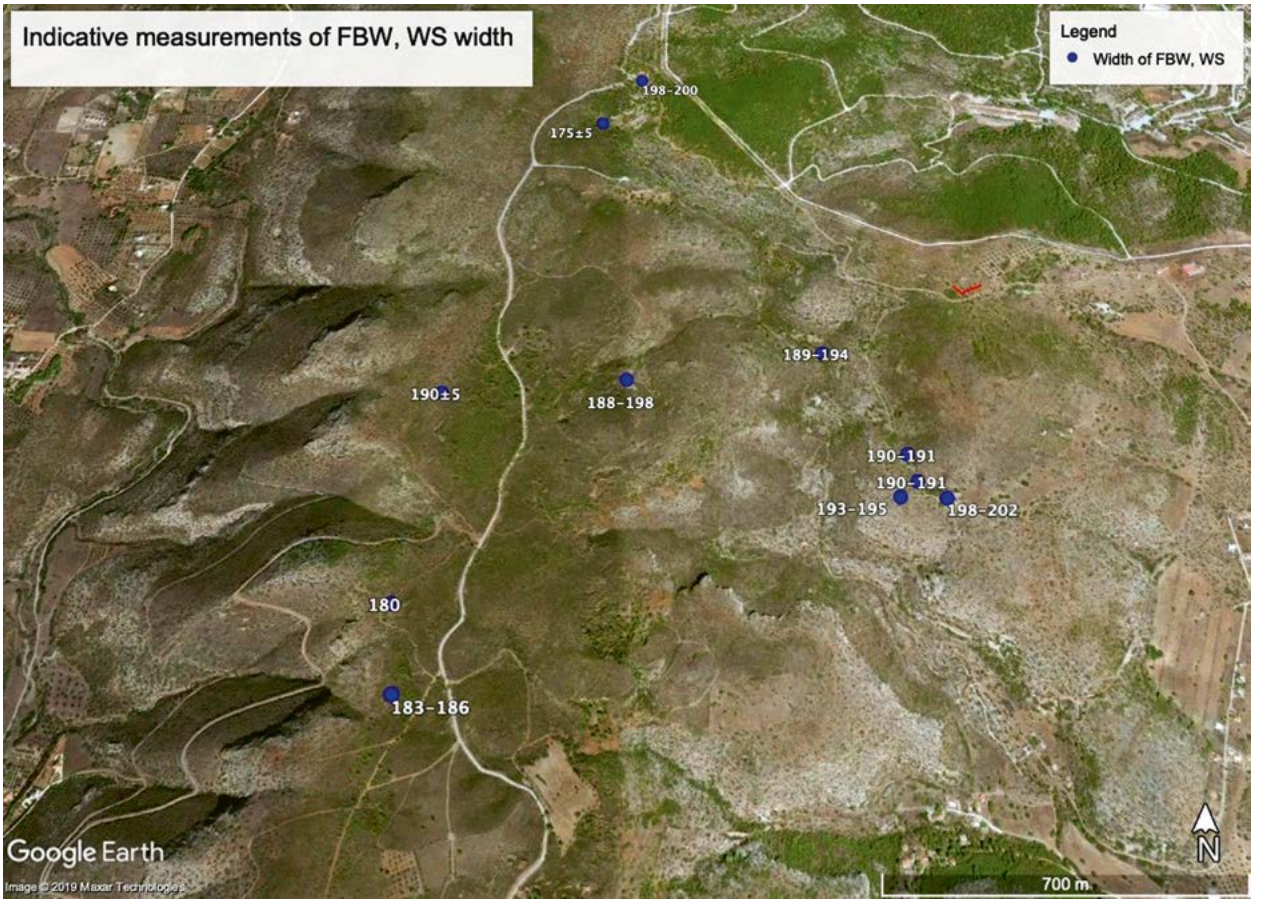

Fig. 4: Indicative example of the spatial distribution of the FBW standardised dimensions as to working space width (Google Earth with additions by A. Kapetanios).

Stage 2

This stage corresponds to the typical "type I" FBW which has been widely discussed (Cordella, 1869; Négris, 1881; Παπαδημητρίου, 1992; Photos-Jones and Jones, 1994; Kakavoyannis, 2001) and there is no need to comment upon it on the present occasion.

In stage 1 *katharistéria*, even if considered experimental, ore-processing in the context of silver production had already entered a "standardisation mode", as evidenced by the dimensions of the working spaces (c. 185–195 cm, taking into account erosion and ware, Fig. 3), which, as aptly expressed by Papadimitriou (1992, p. 193), were kept in "religious piety" for as long as any stage/type of *katharistérion* was constructed (Fig. 4). Standardisation is, of course, appropriate for large-scale massive processing. Then, if experimental, what did ancient metllurgists experiment for?

The significant differentiating structural characteristic between the stage 1 and 2 structures is that:

- in stage 1, *katharistéria* are adapted to an existing geomorphology, hence the irregular distribution of their components, usually hewn into the bedrock, whereas
- in stage 2, *katharistéria* are constructed after the existing geomorphology has been transformed by digging and building in order to be adapted to a preconceived standardised type.

The emergence of stage 2 *katharistéria*, in my opinion, seems to be the result of an effort to achieve the greatest possible standardisation for all parameters related to the process of ore cleaning – i.e. enriching – using water. This affects all practices linked with the Laurion metallurgy chaîne opératoire, i.e. practices and actions undertaken at the spot, as well as others involving large-scale landscape structuring such as water-management. High standardisation could allow consistency in the procession time for certain quantities of certain ores, ground to a certain particle-size. This means labour-cost efficiency and production optimisation. Standardised orientation, plus standardised distribution of FBW and their cisterns within a valley optimises water-flow control, water distribution, evaporation rates and, therefore, water-management on a very large scale.

In brief, the transition from stage 1 to stage 2 *katharistéria* reflects a movement towards great standardisation, optimising the exploitation of scarce water resources and of manpower, and thus reducing the need for highly specialised personnel; only a few of high-value-specialised

Fig. 5: Distribution of stage K–3 (type II) FBW and G–2 Circular Mills (Google Earth with additions by A. Kapetanios).

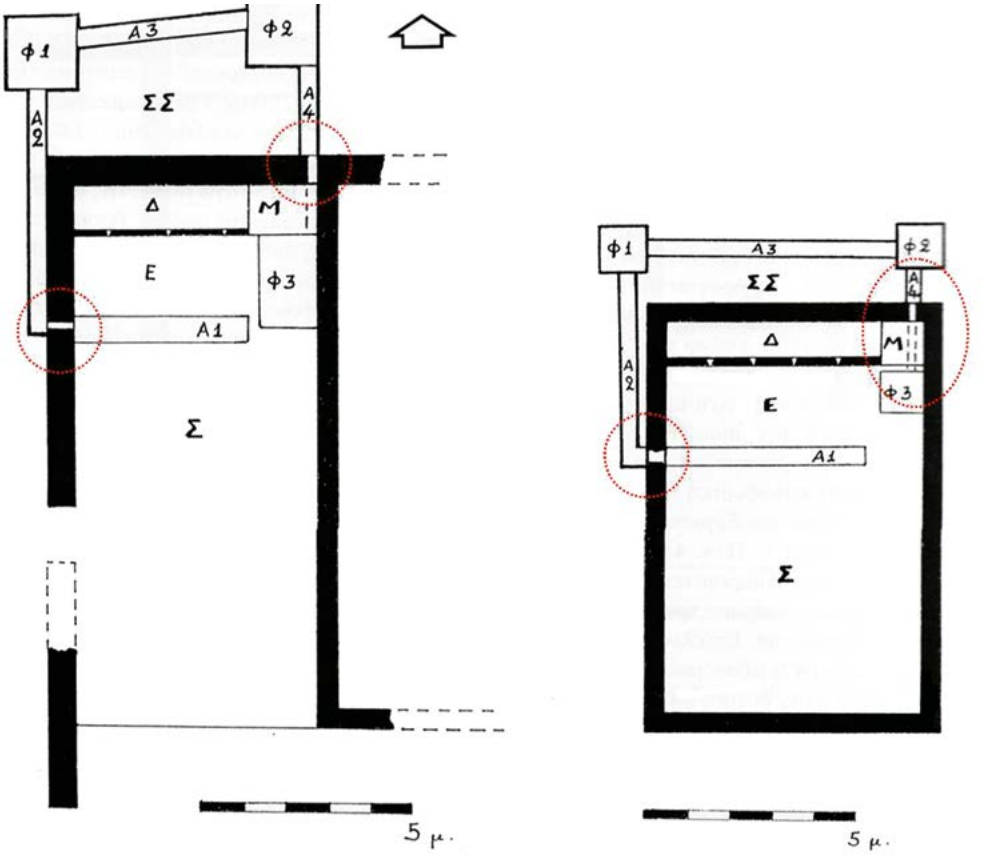

Fig. 6: Variations of the K–3 (type II) layouts (Spitharopousi II and III, after Kakavogiannis 1991); red circles mark tubularopenings (additions by A. Kapetanios).

Fig. 7: K–3 ("type II") tubular opening marked by red circle; Katharistério Spitharopoussi IVb (photo and addition by A. Kapetanios).

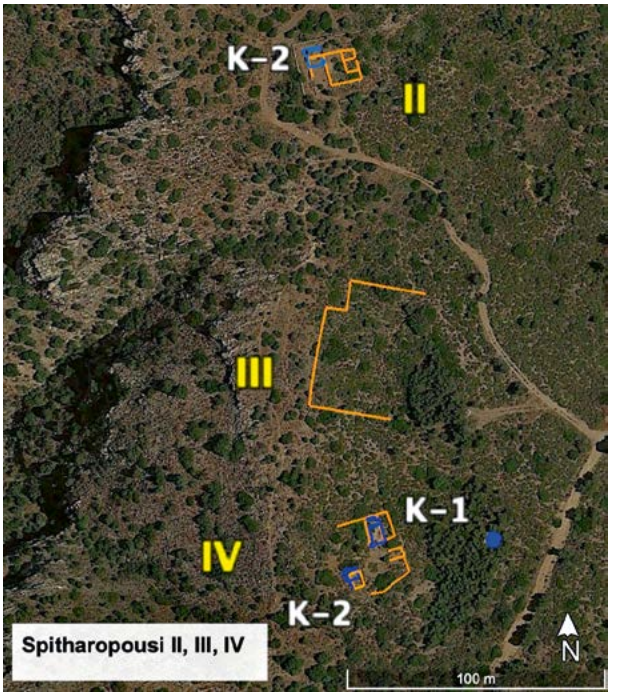

Fig. 8: Spitaropoussi sites, katharistéria II, IV (K-2/"type I" and K-3/"type II" in the same anclosure) and building III (Google Earth with additions by A. Kapetanios).

slaves, such as the famous one talent-worth Sosias from Thrace, owned by Nikias Nikiratou (Xenophon, Poroi IV.14), would suffice to orchestrate many groups of unspecialised workers/slaves. And the *katharistéria* would still work with high precision.

In this context, control over manpower and water, through standardisation of structural features and processes, implements effective mass-production and establishes well defined power relations.

Stage 3

The few specimens (ten identified to date, Fig. 5, blue disks) of the so-called type II FBW seem to be rather idiosyncratic as each one presents a different layout (Kakavogiannis, 1991); they do share, though, the same standardisation with type I, as regards working space dimensions. Its interpretation as a predecessor of type I FBW has been criticised.[7]

All type II FBW share two features which differentiate them from the typical type I FBW:

- an extreme variation in positioning the sedimentation tanks (no pair bears the same positioning (Fig. 6).
- tubular openings interconnect channels and sedimentation tanks in a variety of ways (Fig. 7).

It is possible that these two are causally linked. There seems to be an effort to deal differently, but in a systematic way, with subsurface dilution as opposed to its surface, allowing for the first to move on in the circuit, while keeping the second, or the reverse. The resulting non-standardised (as to outline) type, may reflect experimentation to optimise such a process. Taking into account Papadimitriou's scheme, which describes a shift in practices by assigning significant part of the production processes to the exploitation of accumulated by-products, mainly litharge (Papadimitriou, 2008; 2018), type II FBW may indeed place themselves at the dawn of such a transition, even though we cannot decode, yet, their functional purpose. Their small number (relatively to the widespread type I), the general co-existence of both type I and II FBW in the landscape as remains of the last period of the *ergastêria* use (Kakavogiannis, 1991, p.16) and, more significantly, their co-presence in the same *ergastêrion* defined by its enclosure (Fig. 8) corroborate to placing type II in a third stage in the evolution of FBW, co-functioning with the earlier type I (stage 2).

Stage 4

A series of alterations by additional elements (slabs, stones, etc) have been described in various cases by the excavators of *ergastêria* (Zorides, 1980; Oikonomakou, 1979; 1991; 1997; Kakavogiannis, 1995). They are defined by various, rather coarse modifications of the existing type I and II FBW components. Even if not reported in detail, it seems safe to suggest that they are mainly associated with arrangements in channels of the *katharistérion* circuit.

I would divide these post-construction additions into two kinds:

- First, there is a single slab dividing the first ("collection") channel (parallel to the feeding tank, in front of the

Fig. 9: (a) A slab dividing the feeding tank in two (K–4a, Souriza). (b) Slab with U-notch in situ, held in position by lining slabs (K–4b, Spitharopoussi, ergasterion "Kordella"). (c) Vertical slabs dividing the first (collection) channel in four; notch is visible at the upper left corner of the slab (K–4b, Spitharopoussi, ergasterion "Kordella"). (d) A slab with the typical notch found as one of a tomb's covering stones (Late Hellenistic Cemetery at Limani Passa), (photos and additions by A. Kapetanios).

working space), or the feeding tank itself into two compartments (Fig. 9a). In the first instance, this has been interpreted as a device to process separately powdered litharge and ground tailings, but within the same FBW, aiming at keeping the litharge washing residues in the first compartment, while allowing water to overflow to the second compartment, where the tailings' washing residues were driven into (Papadimitriou, 2018, pp.194 – 195, fig.6).

- Second, roughly hewn slabs are placed vertically in the *katharistérion* channels (the first channel so far), dividing them into more than two compartments[8] (Fig. 9b,c). Schist is almost exclusively used, probably due to its naturally impermeable quality. These slabs are set in place and stabilised by other slabs lining the channel's walls (as a second layer, Fig. 9b,c). They allow overflow through roughly shaped notches, either as a cut at one of the upper corners (Fig. 9c), or, most commonly, as a U-shaped notch at the centre of the upper side of the slab (Fig. 9b). Such notches are not present in the slabs of the first kind, above. The setting could be interpreted as a device for producing gradually higher concentrations of light material, the highest accumulated in the last compartment, a technique which is known to have been applied widely as, for example, in the extraction of clay. Schist slabs of this type, bearing the characteristic notch, have been recorded astray on the surface, in various locations in the Laurion area.

Are these two classes synchronous? They could be, as they both have been found standing in position, as the last phase of use of *katharistéria*, prior to their abandonment. They seem, though, to address different processual targets. For the present classification, I will consider them as stage 4a and 4b, respectively. Can they be dated?

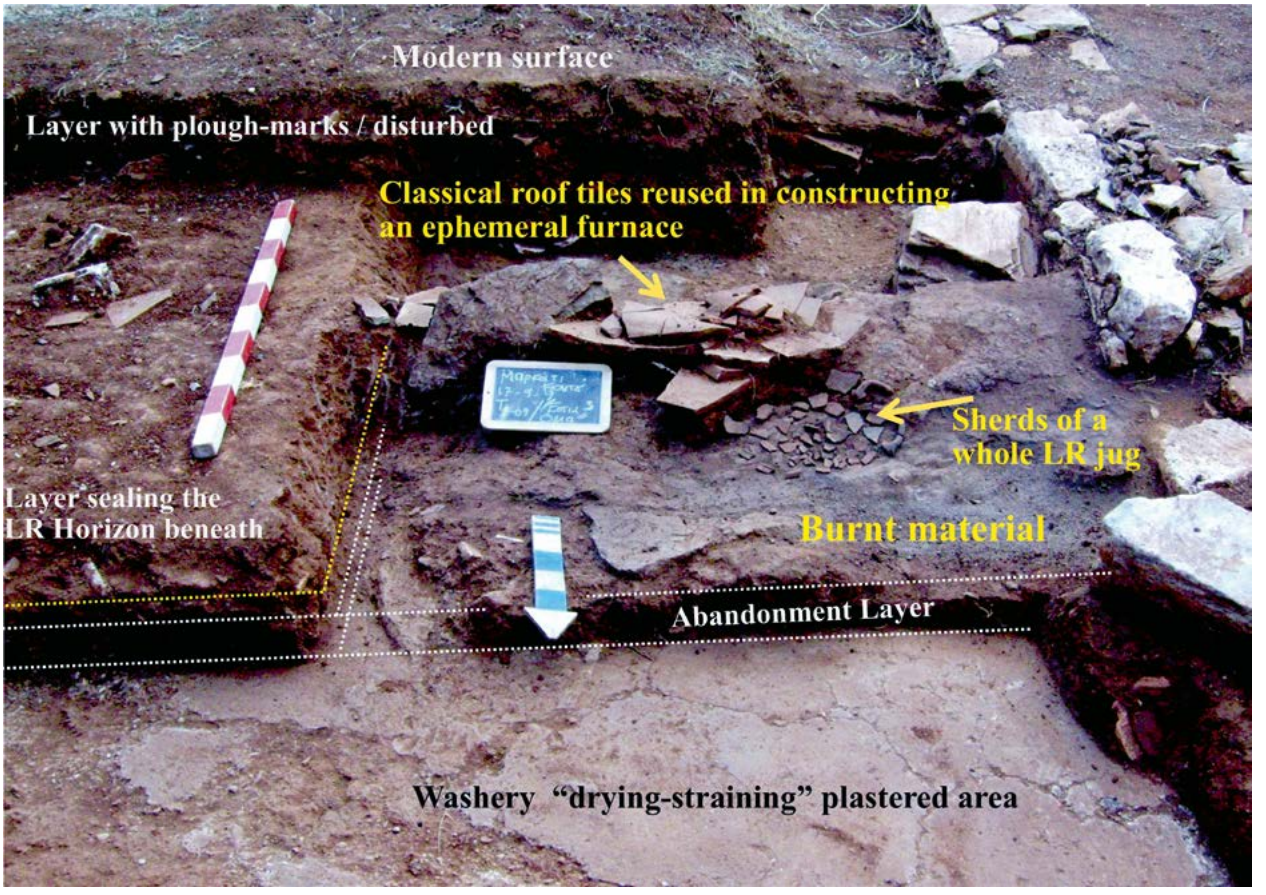

Fig. 10: Remains of short-scale and short-term metallurgical activities, with a broken LR jug, on top of the abandonment layer covering a K-2 (type I) FBW, at Merkati-Stephani, Thorikos (photo and additions by A. Kapetanios).

Again, direct dating of their placement in the channels has not been possible yet. A slab, characteristic of the stage 4b alterations, was found among those covering a pit grave (Fig. 9d) excavated in a late Hellenistic cemetery at Limani Passa (Kapetanios, 2010, pp.150–155; 2013, pp.193–196). The tomb is dated by its grave goods to the late 2nd/early 1st century BC. Therefore, for the time being, we may consider this date as a *terminus ante quem* for the stage 4b rearrangements in FBW being introduced and operating.

Stage 0

To the stages described above I should add one more in the beginning: What was there before the invention of FBW? Wooden versions, or simply nothing? Or both? The possibility that prior to FBW, people were directly smelting high-grade ore and that *katharistéria* came about when the processing of low-grade ore became necessary was put forward in the past (Kakavogiannis, 2001, pp.336–337); current geological and mineralogical research in Laurion (Ross, et al., this vol.) seems to support the availability of high-grade mineralisation, suitable for direct smelting (Ross, et al., this vol.; personal communication). This stage should be included as stage 0.

Stage codification[9]: K–0, K–1, K–2, K–3, K–4a, K–4b

Stage of post-abandonment (PA) alterations in ergastêria

This is an 'interposed' stage, only indirectly linked to the *Katharistérion* itself. It is inserted here, because it has been identified in *ergastêria* excavations as a post- abandonment horizon, usually close or over the katharistéria structures.

Small-scale metallurgical activities have been identified on top of abandonment layers (Fig. 10) in *ergastêria* or as intrusions to these layers; a small roughly shaped furnace, metallurgical residues and a broken pot (in the best instance) seem to form a pattern of a certain practice which could be read as scavenging ancient plynites, litharge fragments, scoriae, or whatever could be re-smelted to produce even small quantities of, possibly, lead. In two examples of such cases, at Skitzeri and Markati, in the wider area of Thorikos (Salliora-Oikonomakou, 1997b, p.127; Kapetanios, 2013, p.187) direct dating is achievable, as they represent small closed contexts, in which pottery is of Late Roman date. At the *ergastérion* Ary 63, people dug into the abandonment / destruction layer

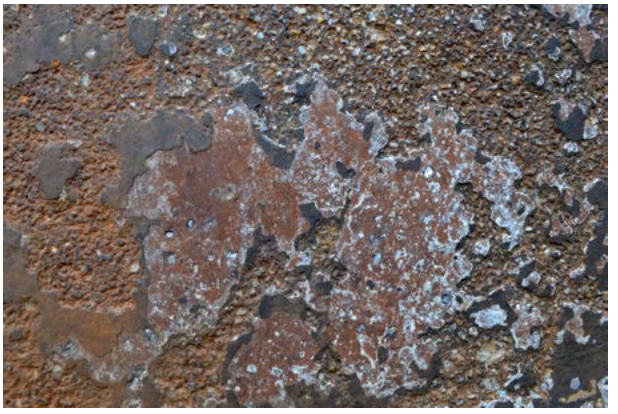

Fig. 11: Two phases of the ultimate waterproof layer of the hydraulic mortar/plaster lining in a cistern (Haghia Triadha, Souriza); Pl–1: the reddish ("litharge") lower layer; Pl–2: the blackish ("manganese") upper layer (photo by A. Kapetanios).

accumulated above its *katharistérion*, probably looking for exploitable residues, and left a broken pot which dates this one-off action again to Late Roman/Early Byzantine times (Hulek, this vol.).

For the sake of the present classification, I will consider this stage as PA-stage.

Stage codification: PA

Hydraulic plasters and mortars

Hydraulic mortars and plasters, being crucial and characteristic components of the sophisticated hydraulic technology applied in the huge network of Laurion *ergastêria*, seem suitable for stages in their evolution to be traced.

As to the substrate mortar, ongoing research building upon earlier studies, suggests that it is actually a hydraulic concrete with extraordinary properties such as high compressive strength, high density and low porosity (Meimaroglou, et al., this vol.). No stages as to the evolution of this technology have been identified so far. A future analytical comparative study between the Laurion mortars and those discovered recently in the well dated water supply system in Piraeus (Chrysoulaki, et al., 2017) could reveal possible technological evolutionary steps.

On the other hand, a twofold variation of the finest waterproof film covering the *katharistéria* and cistern's hydraulic mortar substrate (concrete) has been recognised (Papadimitriou and Kordatos, 1995, p.283; Papadimitriou, 2008, p.116). The two versions differ in that litharge is exclusively present or conspicuously prevailing in one of them, whereas manganese with a lesser presence of litharge characterise the other. It has been proposed that the second version is linked to the period of the cistern's construction, on the basis that litharge would have had been in high demand (and thus scarce) at those times (Papadimitriou, 2008, p.119). This association places the manganese-based layer earlier than the litharge one. Within a small-scale pilot survey employing a portable XRF device to examine in situ hydraulic plasters in the area of the Haghia Triadha-Soureza-Spitharopoussi[10], it was found that in some cisterns the two versions coexisted and quite clearly the one containing manganese had been applied atop the litharge-version as to repair it (Fig. 11). This observation reverses chronological sequencing and places the recipe employing manganese at a later stage than that of the litharge-layer (stage 1 – "litharge", stage 2 – "manganese"). The reasons behind such a shift in the ingredients of the waterproof film remains to be investigated. It is apparent that we need to extend and expand in situ measurements with portable XRF and other non-destructive methods (e.g. photography in various spectrum frequencies, in situ microscopic observation and photography) and keep on documenting hydraulic plasters, mortars and their constituent elements which, macroscopically, do present observable differences. After statistically significant numbers of discrete measurements will be accumulated in a database, we might start developing detailed sequencing by comprehending technical details linked to the evolution of this hydraulic technology.

The exceptional "hi-tech" characteristics of these materials, applied to such an extraordinarily large-scale, result to high-standard, accurate and optimised management of the water resources available in a dry area. This management takes equal care to handle effectively the large scale hydrological networks (catchments and ravines, geology and geomorphology) and the small-scale water use within an *ergastêrion*, through recycling. *Katharistéria* and cisterns covered with these materials make feasible water management that certainly well exceeds the annual cycle.

Stage codification: Pl–1 (litharge), Pl–2 (manganese)

Circular mills

These few (eight identified so far) structures (Fig. 5), initially considered as "helicoid ore-washeries" (Konophaghos and Mussche, 1970; Tsaïmou, 1979), or devices for the homogenisation of ore to achieve effective briquettes for smelting (Tsaïmou, 2008), are now proven beyond doubt to be circular mills (Papadimitriou, 2015; 2016; Nomicos, 2021). Their interpretation as such has been linked to a shift in production towards the exploitation of metallurgical by-products and especially litharge (Papadimitriou, 2008; 2012; 2018, pp.192 – 197). We cannot be sure whether grinding litharge was the purpose of these structures originally; we are definite, though, that this was their use at the time of their abandonment as, at least in the case of Ary II, litharge can be still seen almost embedded into the mill's channel, and accumulated at one of the corners of its square enclosure (or room-walls?) (Papadimitriou, 2016, p.115).

Corroborative argument derives from the gold-mining sites of Samut and Compasi in Egypt's Eastern Desert.

Corresponding structures – one of them almost identical to the Laurion examples – have been identified there, and their use as mills to achieve powder-like ore is attested (Redon-Faucher, 2015; 2016). In a manner reminiscent of Laurion, their dating is uncertain, as these mines were operating almost constantly from the middle Kingdom era down to Roman times and their by- and sub-products were re-exploited in the 20th century.

Direct dating of these mills is (again) currently not possible (cf. Konophaghos and Mussche, 1970). K. Tsaïmou links these constructions with the pottery retrieved from excavations at Bertseko and Ary, ranging from late Classical to Roman times (Tsaïmou, 2008). However, this is just an estimate on the basis of a general overview of the excavated pottery and no detailed pottery data has been available, as yet. In any case no datable finds have been linked to the construction of the circular devices. Papadimitriou infers a similar date range (early 3rd century to Roman times) on the basis of his chronological scheme (see further below) for the emergence of the intensive exploitation of secondary (by) products and especially of the litharge (Papadimitriou, 2018).

Circular mills have been found close to type I (stage 2) FBW but not to type II (stage 3). This has probably no chronological significance but hints to operating and processual differences between all these devices: Circular mills have been found attached to smelting furnaces, whereas K-3 FBWs not (Fig. 5). Furthermore, we do know that, for some period of time, all three did operate simultaneously.

In the context of the present classification, I will consider all pre-existing grinding techniques as G–1 and the introduction of the circular mill as G–2. G–1 techniques kept on being employed contemporarily with G–2 mills.

Stage codification: G–1, G–2

Mines and shafts

The construction (digging) of these extensive works cannot be dated directly, so far. Systematic investigation of mine galleries and shafts is currently at an apex. New data are being accumulated, among which the recording of toolmarks and digging techniques. A study of toolmarks and quarrying techniques towards developing an evolutionary typology, which could contribute to direct dating, is still in the very beginning (Tziligkaki-Stamatakis, 2018). First, we should investigate whether there are intra-site differences (i.e. differences in toolmarks and techniques between different Laurion galleries and shafts).

Currently available datable material retrieved from mines is almost exclusively lamps, found on top of the exposed surface; even if no stratigraphic contexts have been available as yet, these finds are quite safe as *termini ante quos,* being found deep in the galleries; they present two chronological peaks: one in classical times and one in Roman to Late Roman times. Classical lamps of an exclusively and definite 5th century BC date are not known so far. In contrast, the most common finds are the fourth century "inkwell-type" lamps and especially those considered late versions of the type (there is, however, uncertainty as to such a distinction being possible; Blondé, 1983, pp.25–26). Such peaks are also visible in material related to mine III at Thorikos (Blondé, 1983, p.170). The same pattern emerged during the exploration of the Esperanza mine near Kamariza (Vaxevanopoulos, et al., in prep.).

The presence of lamps cannot automatically be translated as mining activities. For example, it is very well documented that in periods of great danger due to warfare or piracy and raids, people sought occasional or even lengthy refuge in such places; a good example comes from the Eupalinos aqueduct in Samos (Kienast, 1995). If for the 4th century BC it is almost self-evident that mining activities occurred, it is not for the Roman/Late Roman times. Certain sets of silver jewellery retrieved from 39 out of the 84 excavated tombs in the extensive Late Roman cemetery, at Panormos (Oikonomakou, 1999) could be considered to corroborate primary silver production for this period. The question here is, whether this clear whitish silver could, alternatively, be derived from the liberation of pure silver from within litharge (Papadimitriou, 2008; 2012). Further analytical studies of these artefacts as well as of the differentiating characteristics of the litharge deriving silver (if there are such to be found) seems to be a way to follow, in order to answer such questions.

Summarising, with the exception of the disturbed, mixed filling at the entrance of Mine III (from EH to Archaic and later), which includes late archaic lamps, mine galleries and shafts could be arranged in four stages: stage 1 – construction; stage 2 – 4th century BC use; stage 3 – unknown; stage 4 – Roman/Late Roman presence.

Stage codification: M–1, M–2, M–3, M–4

We should keep in mind that these works are products of very hard and time-consuming human labour; the tens of kilometres of the gallery networks and the hundreds of shafts cannot be all synchronous; what is the time span of their construction? Was there an apex? Besides surveying galleries and shafts, detailed investigation of contextual information regarding, for example, the peak of slave population in the area may contribute to seeking answers for these questions; further landscape survey combined with mortuary and bioarchaeological studies are needed for such a task.

Synchronisations – phasing

Phasing A – independent sequence

An effort to draw correspondences between all stages described above, and to outline seven successive phases is presented in Fig. 12a.

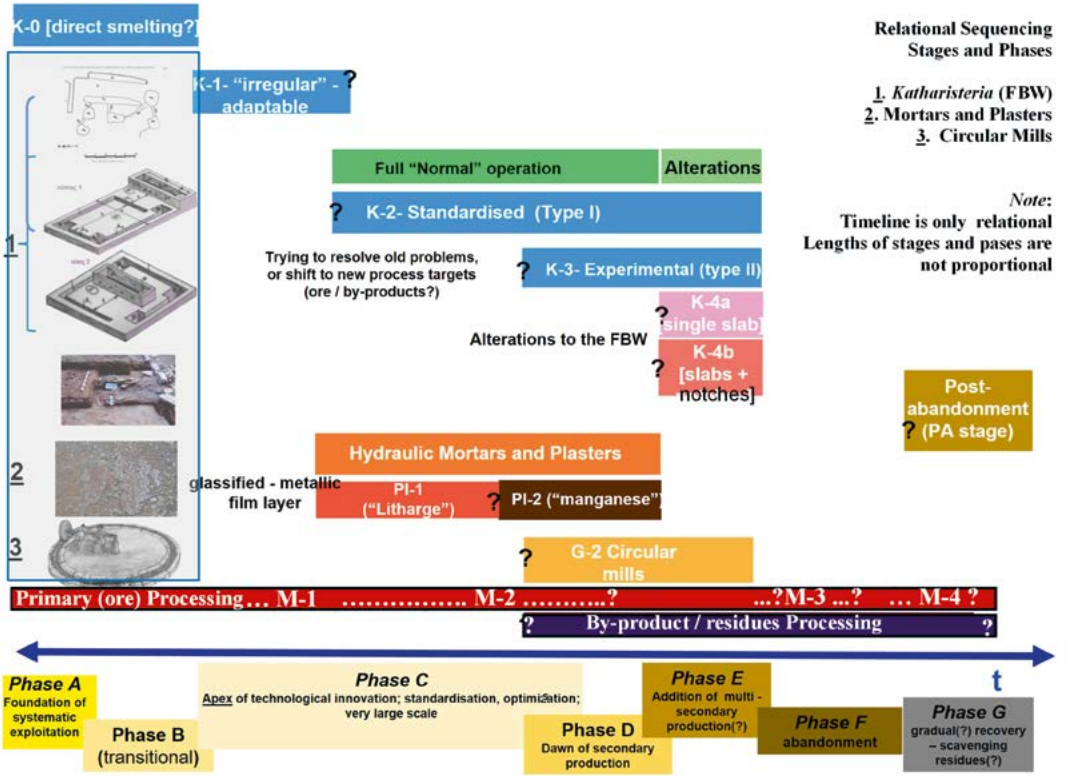

Fig. 12a: Relational Sequencing of archaeological features. Question-marks signify chronological uncertainty as to the beginnings and ends of stages (chart by A. Kapetanios).

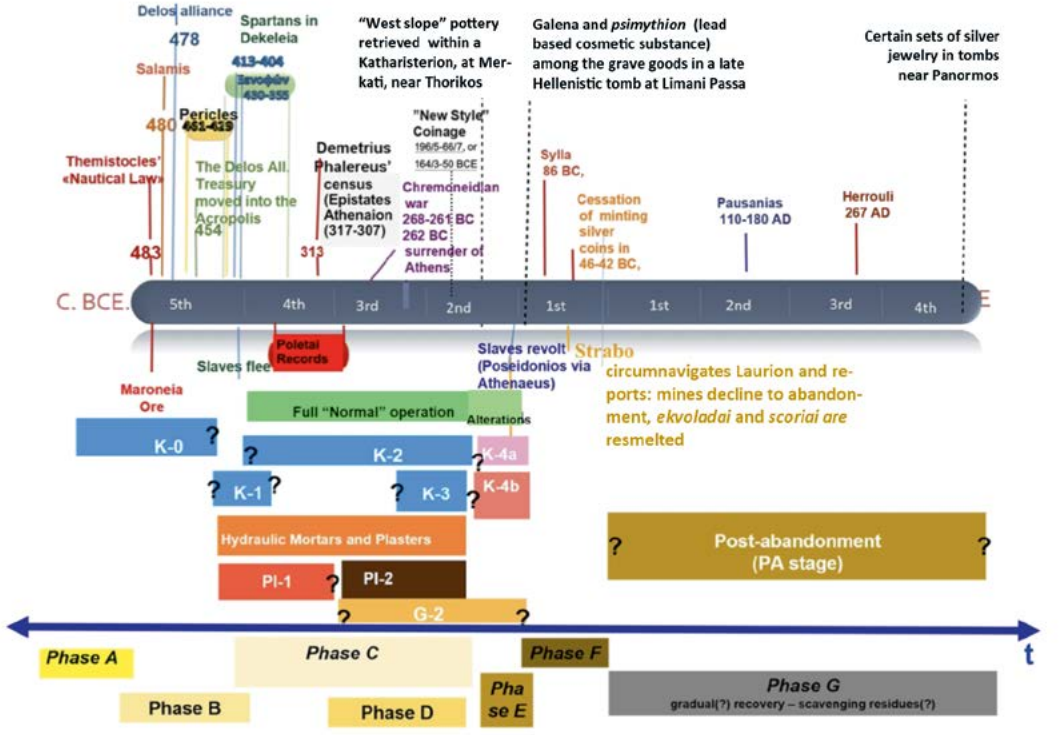

Fig. 12b: Timeline juxtaposing indicative historiographic / epigraphic and archaeological data with the relational sequencing of Fig. 12a. Question-marks signify chronological uncertainty as to the beginnings and ends of stages (chart by A. Kapetanios)

From phase A to C we may discern the formation of suitable contextual conditions for the emergence (with the contribution of technological innovation) and sustainment of an intense interplay between three basic concepts:

- Standardisation,
- Large scale production,
- Control over water, land and human labour.

The way, in which these concepts participate in structuring the Laurion landscape, is examined further below.

Phasing B – indirect dating-links

Next to building an independent sequence, comes the introduction, in it, of links to other "external" datable data, which are presented in Fig. 12b on a timeline.

Indirect dating via available historiographic and epigraphic data[11] still provides the primary chronological thread and the basis for developing synchronies, contextualising, thus, the Laurion mining and metallurgy.

However, establishing synchronies between the historiographic canvas and stages in the evolution of the Laurion economic and social landscape, is not a straightforward process. Let us examine, for example, the suggested linkage between Demetrius Poliorketes's naval blockade of the Athens Asty in 296/5 BC, an assumed banning of silver minting by Antigonos Gonatas – after prevailing in the Chremonidean war defeating the Athenians in 262/1 BC – and the rapid decline, to abandonment, of the Laurion metallurgical and/or mining activities by mid – 3rd century BC (Papadimitriou, 2018, 186). How did such an interpretation emerge? How valid is it? Ferguson (1911, pp.182 – 184) argued that Athens lost the right to issue money, based on inscriptions, which inventory the votives at the Athenian *Asklepeiion* and record "τετράδραχμα αντιγόνεια"[12]. However, as Shear remarks (1933, p.253), (a) there is no evidence that Gonatas confiscated Demosia property such as the Laurion silver mines and (b) these tetradrachms were probably "made in the Athenian mint, but belonged to the Macedonian monetary system", an argument confirmed by the type of the bronze coins issued in the same period (Shear, 1933, pp.253 – 254). It seems thus that, very early on in the debate, a 'pause' in mining at Laurion is far from proven. Furthermore, mines and metallurgical workshops provided metal, not only for coins to be made, but also to be forwarded to the markets as raw material for the production of prestigious artefacts (vessels, arms, jewels) (Kremydi, 2011, p.160). On the other hand, warfare, when raids, land sieges and naval blockades are taking place – as is the case (also) in the 3rd century BC – does affect production, especially when it is implemented in such a large-scale and it is integrally interwoven within such extensive trade and financial networks, as with Laurion. In which manner, though? Indicatively, I refer to trading silver for shipbuilding timber and facilities between the Athenians and the Macedonians, respectively, in the 4th century BC, at least. It has been argued that, in this context, Archelaos, honoured as proxenos and euergetes in Athens, obtained silver for his coinage from Athens so that the Athenians would rebuild their fleet after its destruction at Syracuse in 413 BC (Lykiardopoulou and Psoma, 2000, p.325; Kremydi, 2011, p.164). If we add to such networks that of slave-trade (being highly skilled or not) we may get an idea as to the complexity and extent of these networks.

Material evidence may, nevertheless, hint to some aspects of these effects. The Thorikos hoard (Bingen, J., 1973), for example, buried in 295/294 BC, probably records a response by a certain person or persons to the perilous situation of those years. Does it signpost the desertion of Thorikos, though? A hiatus as to pottery assemblages datable to the second half of the 3rd century, observable in the contexts of cistern 1 and in the so-called industrial quarters (Docter, et al., 2013, p.119; Mortier, 2013, pp.132 – 133, 136, fig.6), seems to correspond to such a narrative. However, in the wider area of the insulae and the theatre, there are pottery types – such as megarian bowls and Coan amphorae – that span over the second half of the 3rd and the 2nd century BC (Mortier, 2013, p.132); the 3rd and 2nd century BC pottery in the ergasterion at Skitzeri (Oikonomakou, 1997, pp.125 – 133) could be a hint that people were relocated to another site (or sites) within the Thorikos valley system and the surrounding slopes (Mortier, 2013, p.138). If this is the case, soon they prospered again as suggested by the 2nd century increase in pottery frequencies at the cistern 1. Besides, this is the century, being its beginnings or its middle, that the "New Style Silver Coinage" was introduced (Shear, 1933, p.252; Thompson, 1961, p.464 – 67; Lewis, 1962, p.275; Kleiner, 1975, p.326; Boehringer, 1972, pp.200 – 204; Mørkholm, 1984, p.38). Furthermore, it is the second half of the 2nd century BC, when a "flood of Athenian tetradrachms" into Macedonia is attested to answer deficiencies of local production due to political and strategic circumstances at that time (de Callataÿ, 1998, p.18).

It is most probable, then, that immediate repercussions of the Chremonideian war are readable in the Laurion material record, further to the military installations at Hárakas and on the Pátroklos island (Lohmann, 1996). What needs further investigation is the spread, the duration and the kind of its impact.

The aforementioned late Hellenistic cemetery at Limani Passa marks the next turning point in a period of change: a shift to Roman trade-routes networks, centred on Delos, which was administered by the Athenians, coincides with political turmoil and the slave revolt in Laurion (Kapetanios, 2013, pp.193 – 196), as reported by Poseidonius, via Athenaeus (Athen. 6,104, 7 – 15). In this account, we learn that the slaves seized the Sounion fort and lived in there, raiding rural Athens "for long". Consequently, there is abandonment of the *ergastêria;* but there is also sporadic scavenging of metallurgical residues visible by Strabo[13] a process to culminate when the Late Roman material culture becomes observable in the archaeological record.

The archaeologically visible and rather opportunistic practice of stage PA, outlined above, is perhaps one of the facets of the Roman to Late Roman revival of human presence in Laurion (i.e. the observable LR presence in the material record), closely related to re-smelting ancient *ekvoládae*, *scoriae*, and *litharge* (Kakavogiannis, 2013; Papadimitriou, 2008; Lagia, et al., 2015). The other, more systematic facet is echoed in the text of an inscription where Ianibelos is hailed as master of furnaces (ἀρχικαμινευτής; IG II² 11697; SEG 13, no. 207; 26, no. 365; Kordellas and Wolter, 1896; Lauffer, 1979, pp. 125. 133 – 135. 168. 175. 178 n.1, 200. 203s.), in the excavated parts of an extensive cemetery with more than a hundred pit graves of this period at Panormos (Oikonomakou, 1999; Parras, 2010), in the foundation of a sanctuary dedicated to Men Tyrant by a slave, overlooking the cemetery (Koumanoudhis, 1898; Kloppenborg, 2012; Lane, 1971, pp.7 – 10), and in the nuclear settlements of the same period at Sounion Plakes (Kakavogiannis, 1977, p.212; 2013, pp.162 – 168; Gikaki, 2015) and at Koulocheri, close to Anavyssos, which seem to specialise in reprocessing ancient metallurgical residues.

We may seek for comparative material in another, purely agricultural area. The seminal Aténe survey (Lohmann, 1993), covering the areas of Legrena, Charaka, Hagia Photini, Thymari and Gaidouronisi to the West and South of the densely built *ergastêria* valleys, revealed and recorded a large-scale agricultural landscape of the apparently agropastoral deme of Atene.

The available data from the surface intensive survey, conducted in the areas of the located farmsteads and small rural sanctuaries, suggest a peak in the Classical period, a dramatic drop (interpreted as abandonment of the farmsteads) c. 300 BC, with the exception of a small metallurgical site on the Legrena coast (recycling metallurgical residues); absence of material culture follows, until another peak from the 4th to the 6th century AD, the latter related to a significant number of sheepfolds and corals (Lohmann, 1993, pp.264 – 266, fig.8, pl.3). This picture corresponds to that of the Laurion mining Demes with the exception of the 2nd century BC 'revival'.

Besides the chronological implications of the discussion so far, it becomes tangible that practices of scale, which feed economic networks of scale – as were these of the 5/4th century BC Laurion – are conceivably sensitive to scale events, such as warfare and political upheaval. The strength of their impact is not, however, predictable nor it is its outcome.

Phasing C – juxtapositions

In Fig. 12b it becomes clear that overlapping of many different evolutionary stages which were sequenced independently, coincides with the density peaks in the material record and potentially linked to some chronologies deriving from written sources, the famous Poletae Records (Crosby, 1941; 1950; Lalonde-Langdon-Walbank, 1991) among them.

Can we employ these relationships that we have established so far to decode further the observable Laurion? At this point we need to revisit the aforementioned three basic concepts: Standardisation – Large scale production – Control over water, land and human labour.

Laurion landscape dynamics: The Demes' spatial organisation model

The structuring principles of the settlement pattern of the Laurion peninsula Demes are the clustering – or dispersion – of habitation/production modules and their linkage and cohesion as a network. Each module encompasses rooms/buildings for people to live in as well as structures and built space to produce. There are two such modules: the *ergastêrion* and the *farm* or farmstead (Kapetanios, 2013, p.189).[14]

The *ergastêria* known in Laurion, so far, are almost exclusively metallurgical (*katharistêria* and *káminoi*), entailing the 'industrial' built components (adequately discussed) plus living quarters (Jones, 2007; Tsaïmou, 1979); in the case of *farms* there are corrals, terraces, threshing floors, wine/olive presses, storerooms, plus the living area, the oikia, (Young, 1956; Langdon and Watrous, 1977; Lohmann, 1993; Goette, 1994). Clustering seems a result of production practices (Fig. 13): *farms* are dispersed as they need cultivable (organised by terracing) and grazing (punctuated by pens and corrals) land; *ergastêria* cluster where the resources needed for their operation were best accessible. Multifunctional *towers* commonly are attached to farm modules and to groups of *ergastêria.* State defence was provided by the Thorikos and Sounion forts[15]*.* Roads and collective centres – such as sanctuaries and *agoras* or the theatre – provided the cohesive force for a society of people living and working in the clustered *ergastêria* or in the dispersed farms. Harbours (Thorikos, Panormos, Sounion) and anchorages were links to sea-route networks. Then there are dispersed tombs, tomb clusters and cemeteries.

This scheme (Kapetanios, 2013, pp.189 – 193) bears in its core the understanding of a deme, not as a nuclear settlement with satellite sites, but as a network of clustered or dispersed modules of habitation / production plus collective foci and it could be considered a model applicable to other Athenian rural demes as well (Lohmann, 1993, p.124; Steinhauer, 2012, p.51).

The clustering of Ergastêria: Metallurgic or hydraulic societies?

The location of *káminoi* on promontories, or on flat land (lowland/coastal valleys or plains) facilitated their supply with fuel (mainly charcoal?) by sea.

Katharistêria had to be near the mines to reduce, by enrichment, the volume and weight of ore to be carried to furnaces; the evolution of water management technology, as described above, clustered the *katharistêria* in the valleys*,* producing a network of dense linear settlement

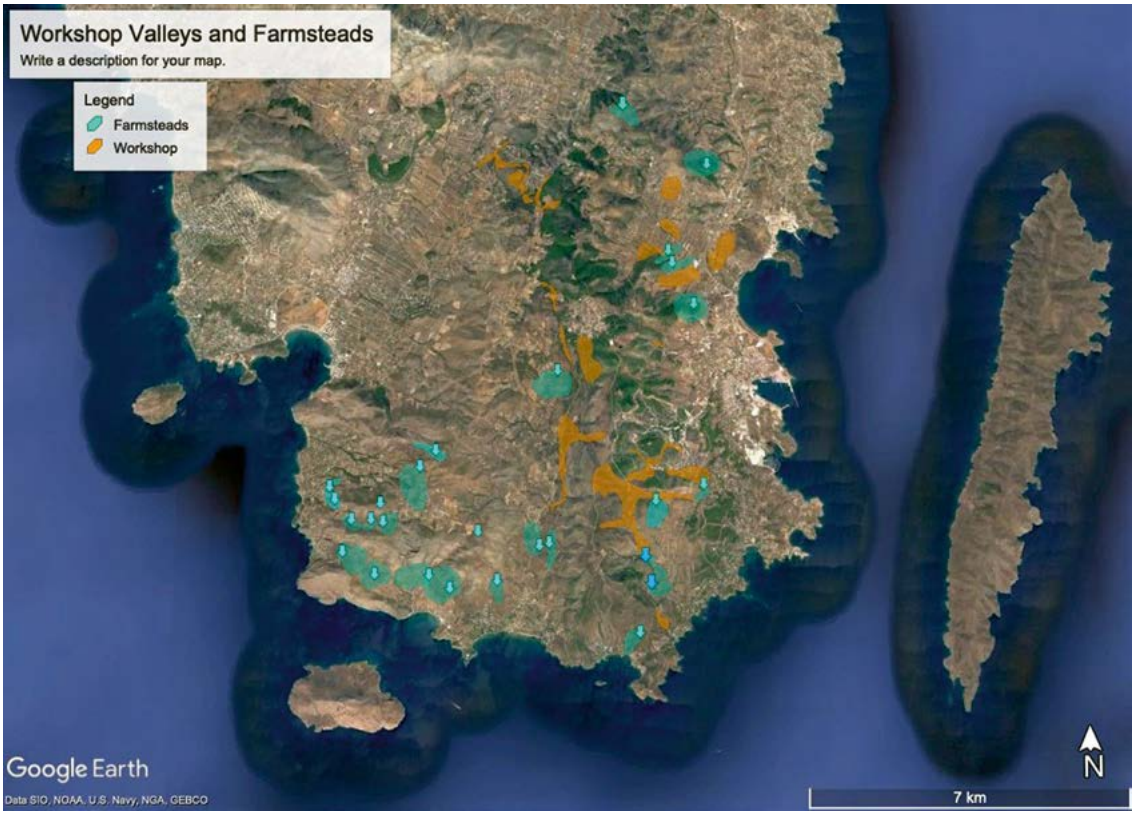

Fig. 13: Dispersion and clustering: the distribution of farms and ergastéria (Google Earth with additions by A. Kapetanios).

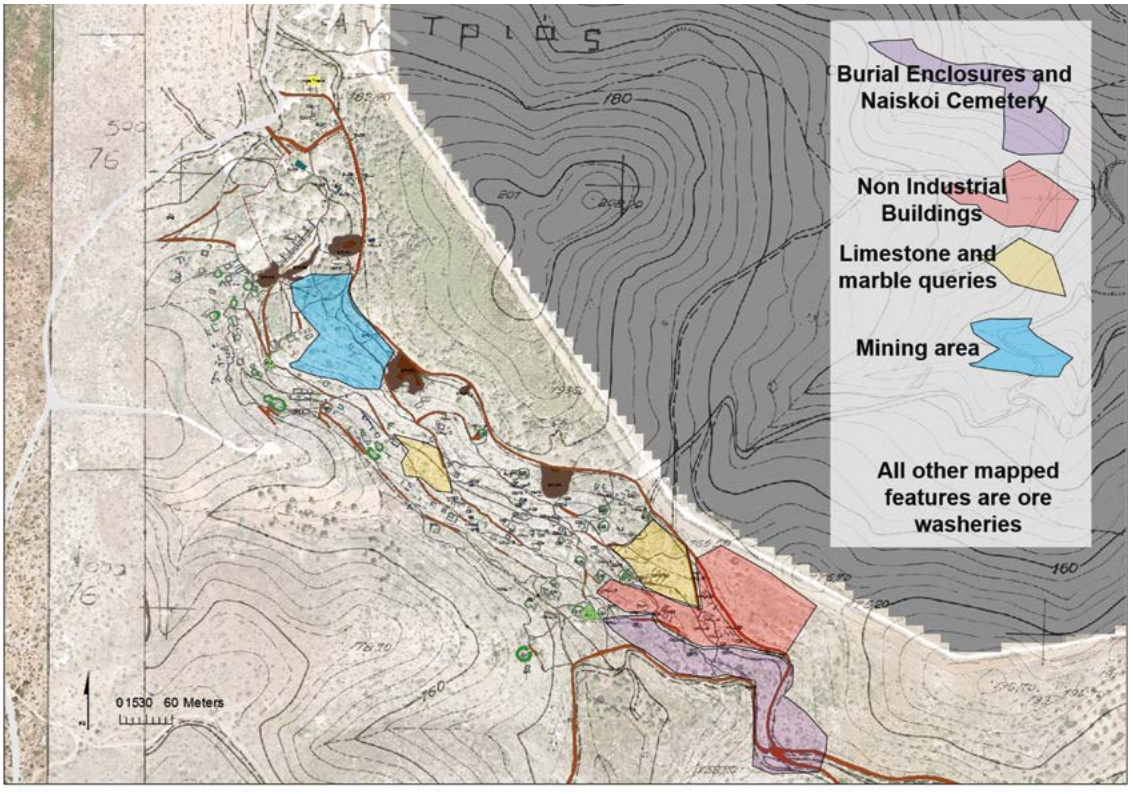

Fig. 14: Typical structure of a valley clustering ergastéria (N branch of Souriza valley system) (compiled basemaps provided by the Hellenic MGS and National Cadastre Service with sperimposed topographic plan and additions by E. Farinetti, L. Koutsoumbos and A. Kapetanios).

Fig. 15: Enclosure on the flat area of the col between Mihale Hill and Botsari (photo by A. Kapetanios).

foci; standardisation and precision boosted production to a very large scale; the largest the scale the greatest the density of the linear valley settlements.

In this manner, the organisation of human built space in certain valleys moved towards 'urbanisation'. Indications for such an emerging urbanisation can be traced in the archaeological remains of the complex internal valley system of Souriza – Agrileza and its surrounding hills (Fig. 14, 16). Two parts of the densely built space do not present industrial characteristics; the north one, extending around a crossroad, with rows or groups of burial enclosures and *naiskos* tombs along all of its branches and an open-air enclosed, probably unbuilt area (Figs. 15, 16) at the flat level of a col overlooking the Laurion East coast and Makrónêssos; the southern one, on the southern and south-western slopes of hill Michális, is built on a terrace created by an impressive ashlar retaining wall with an additional probable defensive role as part of it is structured in a bastion-like manner (Fig. 17).[16] These are hints to central (collective?) foci of the valleys' cluster network (Fig. 16). The well-known Leukios's agora inscription (IG II² 1180) and a *herm* were reported to be retrieved from a stack of tailings somewhere between the two locations (Kordellas and Wolters, 1894, pp.241 – 243).

It is evident, then, that the observable material record is not merely an imprint on the landscape of the socio-economic activities, but it is actively involved, restructuring the landscape via clustering of buildings in ravine valleys, and leading to the emergence of social phenomena such as urbanisation.

It is also active in shaping ideological aspects of the communities involved: If on the map (Fig. 13), depicting the distribution of production / habitation modules (i.e. farmsteads and *ergastêria),* we add the burial enclosures, we will see that there is a corresponding clustering (Fig. 18). This correspondence seems to be linked to issues of ownership and especially land (farm or *ergastêrion*) ownership. Regardless, whether the owner lived in the estate or not (Steinhauer, 2012, pp.50 – 51), the burial enclosure has to be there, as the material manifestation of the lineage, a constant tangible and ideologically laden reminder of landownership and thus its re-affirmation, or, in other words, its legitimation (cf. Snodgrass, 1998, 37,40).

Conclusions

Even if high-resolution chronological sequencing is not currently feasible, due to lack of direct dating of many of the crucial components structuring the Laurion landscape, there is indeed clustering of material evidence to certain periods. This material record is intrinsically linked to the restructuring effect of technological advances, such as hydraulic works and inventions and metallurgical innovations, illustrated in the comparative chart.

The overall phase-scheme presented here seems to largely confirm, by qualifying them, the coarse lines of the chronological framework we have been familiar with for some time now:

- *Phase A*: Indirect echoes of the 6th century BC; direct smelting(?); the landscape probably dominated by farms, roads, cemeteries, sanctuaries.
- *Phase B*: 5th century BC, obscured (probably due to the overwhelming material presence of the following century); in coarse terms, things proceed with production and landscape organised as in Phase A; the rich Marôneia deposits probably intensified exploitation; large scale mining works; probably large numbers of slaves; high grade mineralisation gradually moves to exhaustion(?) which coincided(?) with the Dekeleia events and the fleeing of slaves. Questions that arise: when did Athenians move from exploiting visible deposits (even some 3rd contact deposits were visible on the slopes of the hills) to underground prospection?
- *Phase C*: most conspicuous peak in the 4th century BC (probably 2nd half); triggered by Xenophon's plan(?); *Poletae* records document administrative meticulousness; intensification of the exploitation of low-grade mineralisation(?); very large numbers of slaves (Demetrius Phalereus's census[17]);

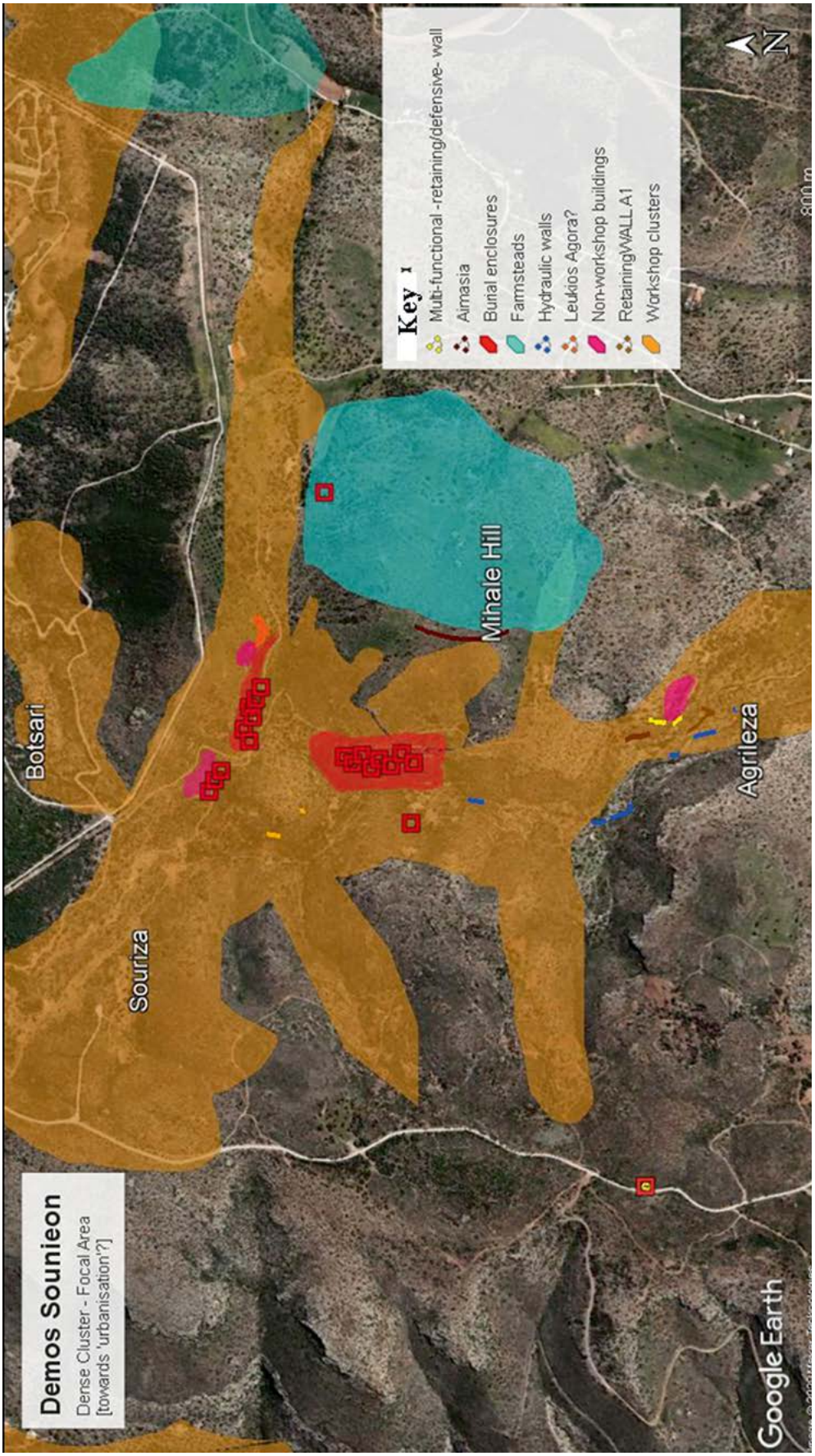

Fig. 16: The area presenting characteristics of a collective locus (Vouno Michali col and its southwest slope) (Google Earth with additions by A. Kapetanios).

technological breakthroughs – the 'hydraulic revolution'; reorganisation of the landscape; dawn of urbanisation; huge quantities of tailings and by-products have already been accumulated; the dawn of metallurgical exploitation of by-products (?).

- *Phase Da-b*: an apparent rapid decline in the 3rd century BC (esp. its second half); metallurgical exploitation of by-products (?).
- *Phase E*: a revival in the 2nd century BC; intensification of the metallurgical exploitation of by-products (tailings, litharge); large number of slaves.
- *Phase F*: (Fa) a rapid decline at the beginning of the 1st century BC; shift in economic orientation/ investments; slave revolt (myriads says Poseidonius via Atheneus[18]); (Fb) abandonment to sporadic or less sporadic presence (cf. the lanibelos inscription) for the centuries to come.
- *Phase G*: another peak around 4th to 6th century AD; both haphazard, small-scale scavenging and large-scale systematic metallurgical exploitation of by-products (tailings, litharge and scoriae); a slave founds a sanctuary; extensive cemeteries; nuclear settlements.

This pattern is certainly present in the basic threads of the chronological scheme proposed by Papadimitriou (2018) for the evolution of the Laurion mining/ metallurgical activities.

Further to chronology, the approach adopted here allowed us to delve into fundamental causal relationships and structuring principles in the history of human societies in Laurion:

All stages and phases share the inevitable material presence of the very large-scale works, constructions

Fig. 17: The ashlar multifunctional wall at the SW slope of Vouno Michali (photo by A. Kapetanios).

and technological methods. Their impact in structuring the regional landscape and organising habitation and production (being metallurgical or agricultural) is significant and augmented in the progress of time through the triptych *standardisation – large scale production – control over water, land and human labour.* The exceptional importance of the water-management concepts, practices and built constructions, is conspicuous. It is manifested especially through the 'clustering effect' in structuring the material dimension of the Laurion landscape, but, also, social relations (urbanisation, control) and aspects of ideology (mortuary landscape, 'legitimisation' and sustainment of ownership relations). The certain hydraulic works have landmarked the Laurion landscape palimpsest which is not a passive synchronic presence but constantly and diachronically active. When comparing, for example, the

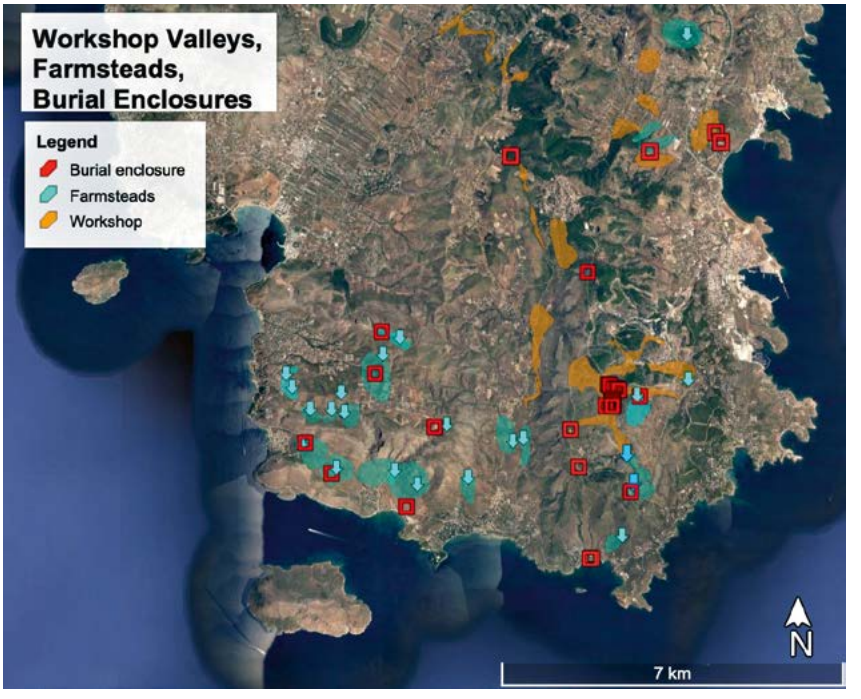

Fig. 18: Farmsteads, Ergastéria, Burial Enclosures (Google Earth with additions by A. Kapetanios).

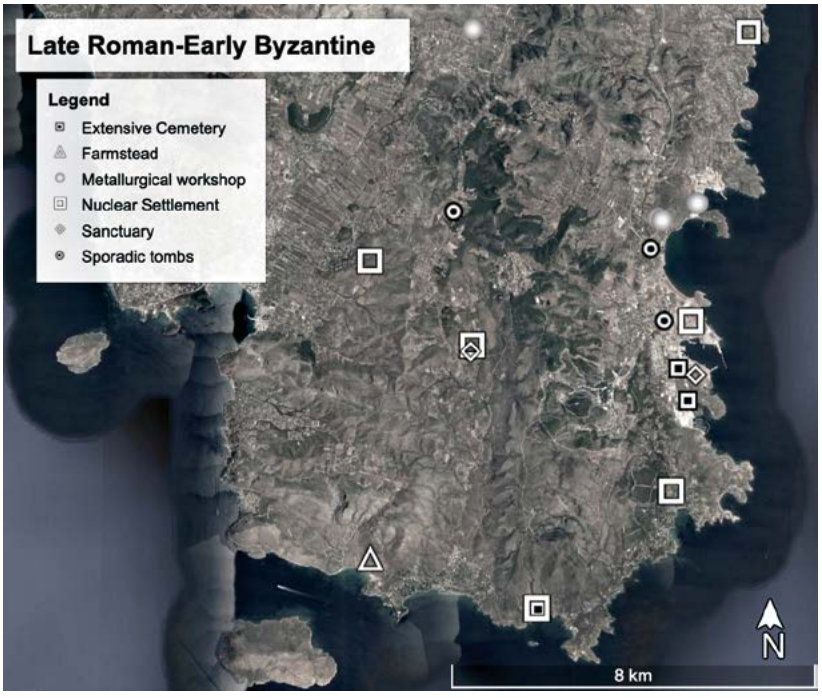

Fig 19: The LR settlement pattern (Google Earth with additions by A. Kapetanios).

agricultural and mining / metallurgical dimensions of the landscape, or Taskscapes according to Ingold (2016), as in the case of Aténe and Laurion, it becomes evident that these large-scale formations produced a landscape which provided the scope for the development of multitudinous communities, via the exploitation of their own past residues, to work, to survive, to prosper, to develop power relations, to collide, to revolt; more than once: 4th century, 2nd – 1st centuries BC and 4th – 6th centuries, 19th – 20th centuries CE. One may even wonder whether we should keep on talking about the Laurion mining and metallurgical societies or the Laurion hydraulic societies.

Except for continuity, as regards the relationship between social groups and metallurgy, economic and political change is also engraved into the landscape: the new trade routes and economic arenas of the Roman world and the shift to secondary (by-product) exploitation in metallurgy, produced *a complete reversal of the settlement pattern model*: the *Demoi* spatial organisation described above as *networks* of clusters dispersed everywhere in the landscape, is replaced by *nuclear* settlements in the Late Roman period, at the perimetry of the Laurion Hills and Valleys (Fig. 19, Lagia, et al., 2015, pp.578 – 579).

In terms of methodology, the present contribution argues that a certain landscape-archaeology approach may function as the cohesive framework for an integrated, consciously interlinked, question-orientated, multidisciplinary research.

Geology, geomorphology, topography, hydrology, technology and humans interact constantly. Communities are organised in space curving the landscape with tools of control, perceiving it and employing its qualities to manifest – impose – negotiate – dispute and rearrange their societies, mainly through power relations. In this context, landscape, surface or underground, is always active. So are all its anthropogenic features: once there, always there, to act!

Acknowlegements

I would like to thank Hans Lohmann, Frank Hulek and Sophia Nomicos for organising the Bochum conference which initiated a much needed, closer interdisciplinary collaboration, opened up fruitful discussions and set the example for keeping on working together to achieve an essential understanding of the complex ancient Laurion. I thank them also for years of cooperation and friendship. Thanks are due to Dr Eleni Andrikou, director of the Ephorate of the Antiquities of East Attica for her encouragement and cooperation for more than a decade at Laurion. The Laurion Archaeological Museum Staff (F. Spanou, P. Makris, M. Athenaeos, G. Andritsakis, M. Tsagifidis, A. Georginakis) has provided a constant support and I am grateful. Special thanks to the conservator of the Ephorate at Laurion open air sites, Yannis Liapis.

Notes

1 All distribution-maps of sites, specific structure-types or features included here, are based on published information, as cited in this contribution, supplemented by primary extensive survey data conducted by the author within a decade (2007 – 2017).

2 The term, literally translated as “cleaning installations”, is applied here to denote the Laurion ancient metallurgical workshop modules (= *ergastêria*), known also as washeries,

Fig 20: Map of the placenames cited in the text (Google Earth with additions by A. Kapetanios).

which operated with water to produce concetrated ore by washing away lighter material. The alternative term "κεγχρεών" (*kenchreôn*, = locale with pulverised material) is employed by Desmosthenes (Contra Pantaenetum, 26.10–11), but according to Harpocration (Kappa, lemma 33) Theophrastus suggested that *katharistêrion* is the proper term to denote the certain Laurion installations.

3 The evolution of smelting and cupellation are not considered in the present occasion as it would demand a significantly more extended version. Furnaces and smelting practices are only indirectly discussed.

4 Indicatively, Kakavogiannis, 1977; 1989; Zoridis, 1980; Kakavogiannis-Oikonomakou, 1995; Saliora-Oikonomakou, 1979; 1985; 1995; 1997a; Oikonomakou, 1991; Kapetanios, 2010; Parras 2010.

5 For a discussion on such indirect dating see Hopper (1961, pp.140–147).

6 There is no need for detailed description of the standard FBW characteristics here as they have been extensively analysed and discussed.

7 This interpretation (Papadimitriou, 1992, p.188) was based on assessing type II as being less effective in facing scarcity of water and rudimentary as to its layout. Kakavogiannis (1991, p.16) countered these two arguments in light of further discoveries of type II FBW, suggesting that we cannot conclude on the type's dating.

8 Multiple compartments have been interpreted as interventions to optimise washing by assigning each to a nozzle of the water-feeding tank; however, there is no one-to-one correspondence evident in all cases and one would expect that such a fine tuning would be an integral part of the FBW (Kakavogiannis, 1991, p.17), especially given its meticulous standardisation to optimisation plan.

9 Stage codification provided is employed in the charts of Figs.12, 14.

10 The survey was conducted in 2016 with Dr Anno Hein (NCSR Democritus) aiming to assess the effectiveness of using portable XRF in the field in trying to resolve archaeological questions. The report on the results of this short investigation is currently in preparation for publication.

11 For a discussion on such indirect dating see Hopper (1961, p.140–147).

12 Today these inscriptions are catalogued and dated as: IG II² 1534 (c. 275 a), IG II³,1 1010 (248/7 BC) and Aleshire 1989, p.249 (244/3 BC), SEG 39:166 (244/3 BC). These dates are lower (up to a decade) than those mentioned in Ferguson (1911, p.184) and Shear (1930, p.253).

13 Strabon (Geogr., 9,1,23): τὰ δ' ἀργυρεῖα τὰ ἐν τῇι Ἀττικῇι κατ' ἀρχὰς μὲν ἦν ἀξιόλογα, νυνὶ δ' ἐκλείπει· καὶ δὴ καὶ οἱ ἐργαζόμενοι, τῆς μεταλλείας ἀσθενῶς ὑπακουούσης, τὴν παλαιὰν ἐκβολάδα καὶ σκωρίαν ἀναχωνεύοντες εὕρισκον ἔτι ἐξ αὐτῆς ἀποκαθαιρόμενον ἀργύριον, τῶν ἀρχαίων ἀπείρως καμινευόντων. (The silver mines in Attica were originally valuable, but now they have failed. Moreover, those who worked them, when the mining yielded only meager returns, resmelted the old slug and tailings, and were still able to extract from it pure silver, since the workmen of earlier times had not been very experienced as to smelting in furnaces.)

14 One hybrid case has been documented: an epikleros (Euthidike) boundary stele inscription, excavated at Kavodhokano, Thorikos, refers to her property as "ergastêrion and orchard" (Oikonomakou, 1991).

15 The Anavyssos fort, the existence of which has been attested to by Xenophon, (Poroi, IV,.43–44) has not been located, as yet. A possible location beneath the thick alluvium of the Anavyssos coastal plain, next to the harbour, would fit the 'fort-harbour' model of Thorikos and Sounion.

16 Masonry and layout of this structure is very similar to the one in Megala Pefka functioning as a retaining and perhaps defensive wall (similar bastion-like features) as well as ahydraulic work controlling the watercourse.

17 Athen. 6,103: Κτησικλῆς δ' ἐν τρίτῃ Χρονικῶν κατὰ τὴν ἑπτακαιδεκάτην πρὸς ταῖς ἑκατόν φησιν ὀλυμπιάδα Ἀθήνησιν ἐξετασμὸν γενέσθαι ὑπὸ Δημητρίου τοῦ Φαληρέως τῶν κατοικούντων τὴν Ἀττικὴν καὶ εὑρεθῆναι Ἀθηναίους μὲν δισμυρίους πρὸς τοῖς χιλίοις, μετοίκους δὲ μυρίους, οἰκετῶν δὲ μυριάδας μ'. (But Ctesicles, in the third book of his Chronicles, says that in the hundred and fifteenth Olympiad, there was a census conducted at Athens by Demetrius Phalereus as to the inhabitants of Attica, and the Athenians were found to number twenty-one thousand, the metics ten thousand and the slaves four hundred thousand.)

18 Athen. 6,104: καὶ αἱ πολλαὶ δὲ αὗται Ἀττικαὶ μυριάδες τῶν οἰκετῶν δεδεμέναι εἰργάζοντο τὰ μέταλλα· Ποσειδώνιος γοῦν, οὗ συνεχῶς μέμνησαι, ὁ φιλόσοφος καὶ ἀποστάντας φησὶν αὐτοὺς καταφονεῦσαι μὲν τοὺς ἐπὶ τῶν μετάλλων φύλακας, καταλαβέσθαι δὲ τὴν ἐπὶ Σουνίῳ ἀκρόπολιν καὶ ἐπὶ πολὺν χρόνον πορθῆσαι τὴν Ἀττικήν. οὗτος δ' ἦν ὁ καιρὸς ὅτε καὶ ἐν Σικελίᾳ ἡ δευτέρα τῶν δούλων ἐπανάστασις ἐγένετο. (and

these certain Athenian myriards of slaves shackled worked in the mines; at all events Poseidonius, whom you are often quoting, the philosopher I mean, says that they once revolted and put to death the guards of the mines; and that they seized on the Acropolis on Sunium, and that for a very long time they ravaged Attica. And this was the time when the second revolt of the slaves took place in Sicily „[104 – 101 BC].)

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