MINING LANDSCAPES OF PREHISTORIC CYPRUS

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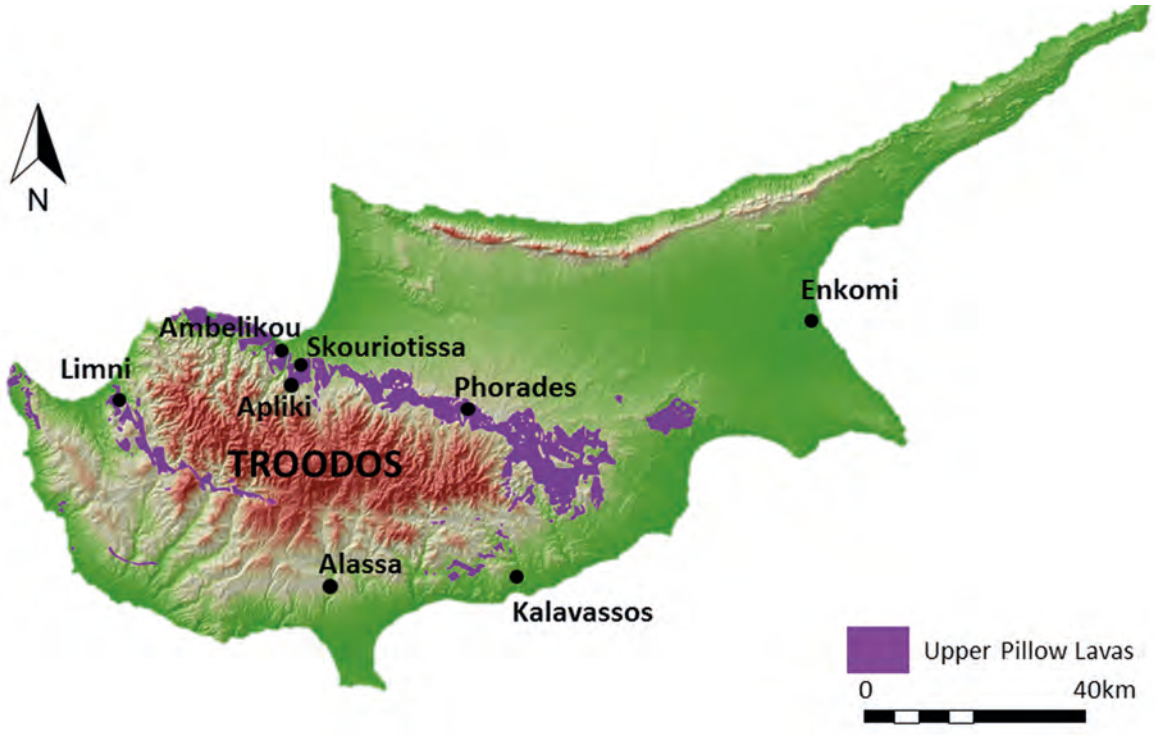
Cyprus, the most eastern island of the Mediterranean became synonymous with copper in Late Antiquity: the Latin word *Cuprum* derives from *Aes Cyprium*, Cypriot copper, the term Pliny used in his book Natural History (*HN* XXXIV.2–4) to describe the pure metal rather than one of its alloys (Rickard, 1930, p.285). This is because Cyprus was one of the main sources for metal for the Old World since the Second millennium BC. This is of course a result of the island's geology and mineral wealth.

The island is naturally divided into four geological terranes: (a) the Kerynia Terrane which largely consists of the Pendaktylos mountain range and runs roughly parallel to the north coast (b) the Mamonia Complex to the south west (c) the circum Troodos sedimentary sequence which encompasses the Mesaoria Plain and (d) the Troodos Ophiolite which covers more than a third of the whole island and rises to a height of 1,951 m (Edwards, et al., 2010, pp.15-16). As the largest and highest land mass, the Troodos is responsible for the island's weather conditions and rain fall (Constantinou, 1982, p.13). In Antiquity, it was equally important for its forests. They provided fuel for the domestic hearths, the pottery kilns and the copper smelting furnaces, but also provided timber for ship building. Most significantly, the Troodos mountain range includes all of the economically-significant mineral deposits (Constantinou, 1992a, p.332). The Troodos' mineral wealth was well known in ancient times as indicated in a passage from Pseudo-Aristotle (Aristotle *Frag. Ph*. 266) who states that: *"... it was found on the island of Cyprus that there was a mountain larger and higher than all others, which was called Troodos …It has various mines of gold and silver, and copper, and stypteria, split and white, and true stypteria. And sory and yeast of gold, and misy and khalkitis and other metals".*

The geology of Troodos is consistent with ophiolite complexes, which are believed to represent fragments of the ocean floor (Constantinou, 2012, p.5). The mountain range was formed through sea-floor spreading and was lifted to its present position due to tectonic movements. Massive copper sulphide deposits, mainly composed of pyrite and chalcopyrite, are located in its periphery in the geological formation known as the pillow lavas (Constantinou, 2012, p.5) (Fig. 1). Because of these deposits Cyprus is considered even today

Fig. 1: Map of Cyprus showing the pillow lava formation and sites mentioned in the text. (Produced by Dr A. Agapiou with digital geological data provided by the Cyprus Geological Survey).



to be one of the five richest countries in copper per surface area in the world (Constantinou, 2007, p.343). Because of the uplifting of the ore deposits and their exposure to the elements, they were soon oxidized to form a gossan or "iron hat" which varies in thickness from several and up to 40 metres (Constantinou, 2012, p.5). The sulphide deposits are often covered by umbers, which have a rich brown colour, and ochres, which have an intense yellow or red colour. These are also significant economic minerals, which were extensively exploited in antiquity as well as in modern times (Constantinou, 1992a, pp.364-365). They were used as pigments for wall paintings and in pottery production from early prehistory until today (especially in the production of Bichrome wares (Aloupi, et al., 2000, p.23)). Other minerals such as chalcanthite, the copper sulphate, were used for the preparation of medicaments and were also systematically collected (Michaelides, 1996, p.144).

The exploitation of the rich Cypriot copper ore deposits lasted for almost three millennia. Recent archaeological evidence clearly shows that the ancient copper industry came to an end sometime around the 8th century AD (Kassianidou, 2011a, p.543). The mines were abandoned for more than a thousand years and it is not until the beginning of the 20th century that prospectors from the US and Europe became interested in Cypriot copper ore deposits after reading the ancient texts (Rickard, 1930, pp.287-288). The mining industry soon became one of the main sources of income for the island as it had been during the Bronze Age. According to Constantinou (1992a, p.339) since the mines opened in the earlier part of the twentieth century and for a period of forty years, 50% of the island's exports were products of the mining industry. In the same period 15-25% of all the taxes collected and 50-70% of income tax derived from the mining industry (Panayiotou, 1989, p.38).

In modern times the copper ore was initially extracted with underground mining. It soon became clear that almost all the deposits had already been exploited in Antiquity: modern galleries invariably came across the ancient workings (Bruce, 1948, p.11). We are fortunate that J.L. Bruce, the resident director of Cyprus Mines Corporation, the company which from 1916 until 1974 had the lease for some of Cyprus' richest ore deposits including Mavrovouni and Skouriotissa, wrote and published in 1937 a paper entitled "Antiquities in the Mines of Cyprus". His publication remains until this day the most comprehensive study of ancient Cypriot mines. In his 1937 publication as well as in the one of 1948 Bruce offers invaluable glimpses of the ancient mining landscapes. He mentions that many of the ancient shafts and galleries had caved in, while old dumps eroded and disintegrated to such an extent that it was difficult to differentiate them from the natural landscape (Bruce, 1948, p.9). This was the case in the Limni mine, which lies to the West of Troodos and encompasses the second largest copper ore deposits of the island (after those of the Skouriotissa-Mavrovouni region). Limni means lake in Greek and the lake that gave the name to this area seems to have been created after the ancient mine had subsided (Bear, 1963, p.74). In the area of Mavrovouni modern prospectors realized that what looked like a promising gossan outcrop covering an area of almost an acre was actually an "ancient stockpile of pyrite ore or low-grade material cobbed off and rejected before smelting" (Bruce, 1948, p.10).

Very little survives of these ancient mining landscapes today. This is because after the fifties, and thus before the first systematic archaeometallurgical investigations on the island which started in the seventies, the mining companies shifted to the opencast method (Constantinou, 1992a, p.342). As a result today there is not much left of the ancient mining landscapes: they have been largely obliterated by the opencasts and the immense spoil heaps (Fig. 2). This is why Bruce's publication in which he describes the vestiges of ancient mines and the artefacts that were found there is so important.

Rather than extensive ancient mining landscapes what remains to bear witness to the extent and intensity of the ancient Cypriot copper industry are impressive slag heaps. It has been estimated that there are 4 million tons of copper slag in 40 different locations spread over the periphery of the Troodos Mountains (Constantinou, 1992b, p.63). As the modern industry shipped the ore abroad and never operated smelting furnaces on the island (Constantinou, 1992a, pp.342-344), copper slag was not produced in recent times. All 4 million tons of slag, therefore, had been produced in Antiquity.

Cyprus was already inhabited from the beginning of the ninth millennium BC, and archaeological excavations at the Pre-Pottery Neolithic A site of Agia Varvara *Asprokremmos* have shown that the first inhabitants of the island were familiar and were exploiting the red and yellow ochres covering the copper ore deposits (McCartney, et al., 2010, p.81). Ochre was also used for the creation of wall paintings, the earliest examples of which date to the Late Aceramic Neolithic, namely to the 7th millennium BC. The best preserved example is the one depicting two human figures which was found in the settlement of Kalavasos *Tenta* (South and Todd, 2005, p.313). It is not until several millennia later, dur-

Fig. 2: The spoil heap of the mine of Mitsero Kokkinopezoula dominates the landscape around Mitsero village.

ing the Chalcolithic period, that the Cypriots began to produce metallic artefacts made of native copper. The earliest artefacts date to the mid fourth millennium BC, they are very few in number, and consist of a very limited repertoire which includes chisels, pins and ornaments such as spiral beads (Peltenburg, 2011, p.3). The Cypriot chalcolithic artefacts are products of a rather simple and primitive technology (Kassianidou, 2013, p.232). In this period another material, picrolite, plays an important role, as it is used to produce pendants and small figurines which are believed to have had a symbolic character (Peltenburg, 1991, pp.111-115). The picrolite source is near the top of the Troodos mountains but it is carried down to the coast by two rivers – the Kouris and the Karyotis (Xenophontos, 1991, p.137). It is thus believed that most of the picrolite used to produce the chalcolithic objects could and would have been collected from the beds of these two rivers. Recent excavations, however, at the settlement of Souskiou *Laona* have shown that some of the picrolite was actually procured at the source (Peltenburg, 2012a, p.48). This is important as it shows that prehistoric people were exploring the Troodos ophiolite in order to collect valuable rocks and minerals.

Things change drastically in the middle of the third millennium BC when Cyprus enters the Bronze Age. These changes are evident in all aspects of the material culture, economy and even mortuary practices (Webb and Frankel, 1999, p.4). Some of the most significant developments are detected in metallurgy. The Early Bronze Age is characterised by a marked increase in metallic objects, which now include weapons as well as a wider variety of tools, and which are deposited as grave goods in significant numbers (Kassianidou, 2013, pp.238-240). This increase in the availability of copper is the result of the development of extractive metallurgy. In other words during the Bronze Age copper begins to be extracted from cupriferous ores, through the process of smelting. In Cyprus the ores are sulphidic and therefore a complicated smelting process is necessary to extract the metal. It is only after this method was mastered, sometime after the beginning of the second millennium BC that Cyprus begins to produce and export significant amounts of copper and eventually takes over as the main source for this metal for all of the Eastern Mediterranean (Kassianidou, 2008, p. 256).

Unfortunately, we know nothing about copper mining and very little about copper production in the Early Bronze Age (Kassianidou, 2012a, p.126). This should not come as a surprise if we consider that the mountains and hills where Bronze Age mines and smelting workshops would have been located have now been completely removed by the modern open cast mines. The only direct evidence for Bronze Age copper mining was found in the mine of Ambelikou in 1942 (Dikaios, 1946; Merrillees, 1984; Webb and Frankel, 2013). Ambelikou is located in the north-western foothills of the Troodos and in the richest mining district of Cyprus which includes Mavrovouni, Apliki and Skouriotissa (Fig. 3). In the forties three galleries were opened up to exploit the copper deposit and in all three of them the miners collected ancient pottery and stone tools (Merrillees, 1984, p.6-8). These includ-

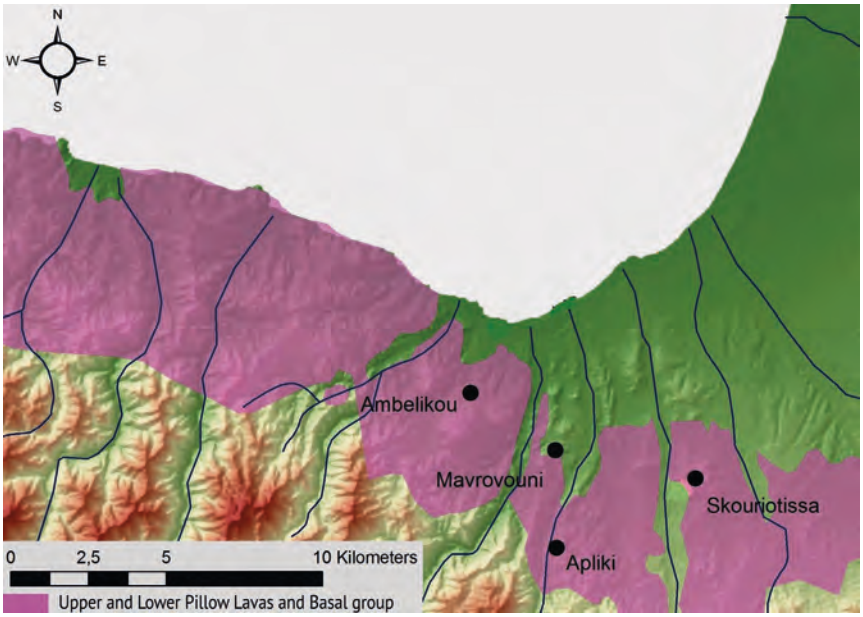


Fig. 3: Map of the mining region of Solea where the mines of Mavrovouni, Skouriotissa, Apliki and Ambelikou are located. (Produced by Dr A. Agapiou with digital geological data provided by the Cyprus Geological Survey).

ed stone axes and what were described as rounded stones with holes or "wheels" which can only be perforated stone hammers. Perforated hammers are specifically associated with mining and are known from other periods and other areas (Kassianidou, 2007, p.280). The shards come from pithoi and jugs of the Red Polished III ware, which date to the Middle Cypriot I period (this roughly corresponds to the 19th century B.C.). The fact that they are undertaking underground mining in this period should not come as a surprise. We know that Cypriots were well trained to dig shafts already since the Cypro- PPNB (8400 – 6800 BC) during which they produced some of the earliest water wells known in the world today (Peltenburg, 2012b, p.71). In the same year, the Department of Antiquities conducted rescue excavations at a contemporary nearby settlement, Ambelikou *Aletri,* which must clearly have been associated with the mine. Although the significance of the site was recognised, a detailed report of the excavation has only just been published (Webb and Frankel, 2013). The excavations of the settlement brought to light stone tools, ores, a double-sided terracotta mould and a crucible, all of which attested to the fact that there was metallurgical activity within the settlement (Merrillees, 1984, p.7). A small fragmentary object may in fact have been a blow pipe. The foreman in charge of the excavation also noted that he excavated an area where he believed that copper production was taking place but this was not investigated systematically. In the last twenty years excavations at a series of Middle Cypriote sites have brought to light archaeometallurgical finds which indicate that copper production on the island began to intensify. At the site of Alambra *Mouttes* which according to radiocarbon dating was occupied between 1900 and 1800 BC (Coleman, et al., 1996, p.335), small quantities of mineral samples, pieces of slag and crucibles were collected (Gale, et al., 1996, p.130). The most abundant evidence for Middle Bronze Age copper smelting, including metallurgical ceramics, moulds and slag was revealed at Pyrgos *Mavroraki* (Belgiorno, et al., 2012). More recently evidence for small scale metallurgical activities were uncovered at the site of Politiko – *Troullia* (Falconer and Fall, 2013, p.108).

Written sources from sites in Syria dating from the 19th to the 17th centuries BC suggest that Cyprus, which is called Alashiya in the texts of its neighbours, exports some of the copper produced on the island to the East (Knapp, 2011, p.250).

It is however, in the second half of the second millennium BC which corresponds to the Late Bronze Age, that the production and export of copper truly grew, reaching a peak in the thirteenth century BC. This marked increase in production (and subsequently export), is due to significant technological developments in the smelting installations: the furnaces were equipped with a system of bellows and tuyères, the use of which led to a significant increase in the operating temperature and thus to the melting of their contents which could easily and efficiently be separated without a significant loss of metal in the slag (Kassianidou, 2011b, p.45).

The innovations in the smelting technology can clearly be seen in the excavated remains of the only Late Bronze Age primary smelting workshop known to us until today. The workshop is located at the site of *Phorades* near the village of Politiko (Knapp and Kassianidou, 2008). The excavation directed by Bernard Knapp and the author uncovered 3 tons of primary smelting slag (Knapp and Kassianidou, 2008,

p.143), hundreds of furnaces (Knapp and Kassianidou, 2008, p.140) and tuyère fragments and more than 50 almost complete examples (Knapp and Kassianidou, 2008, pp.141-142). The use of bellows at Phorades is indirectly revealed: in the inner surface of some tuyère fragments one can often detect droplets of slag which have been sucked in (Kassianidou, 2011b, p.44). A small number of ceramic shards and a series of radiocarbon dates indicate that the workshop was active around the 16th-15th centuries BC, in other words at the very beginning of the Late Bronze Age.

The workshop is hidden in the north-central foothills of the Troodos and was not a part of a settlement. The limited numbers of ceramic fragments, food residues (faunal and floral) and any artefacts that were not in any way related to the smelting activities or were still of use (such as stone tools) indicate that this was a seasonal site which was abandoned once it fulfilled its purpose. The ore that was smelted at *Phorades* was most probably collected from the nearby hill *Kokkinorotsos*. It is located about 500 metres to the northwest and it is clearly visible from the site because of the brightly coloured gossan after which it is named: *Kokkinorotsos* means red rock. On *Kokkinorotsos* there are several inclined adits but their date is unknown as they have not been systematically investigated. Although the possibility that they are modern exploration adits cannot be ruled out, the fact that they are spatially associated with slag heaps which date to the first half of the 1st millennium BC and with *Phorades,* can be used as indirect evidence for their antiquity (Knapp, 2003, pp.136-138). Since *Kokkinorotsos* was not exploited by the opencast method it provides us with a glimpse of what a prehistoric mining landscape would have looked like. Pine trees are still covering the gentle hills which would have been much more wooded in Antiquity. According to the study of charcoal samples collected at Phorades, *Pinus Brutia* was almost exclusively used as fuel for the smelting furnaces (Knapp and Kassianidou, 2008, p.142). Why they chose to place the smelting workshop at a small distance from the ore deposit is not clear but it may have to do with the need to be near a water source: the workshop is on the bank of a small creek and a spring. They would have provided water for the workmen and clay for the furnaces and tuyères. The scale of production at Phorades is small which means that several such workshops would have operated simultaneously around the foothills of the Troodos mountains. The discovery of "Phorades- type" slag in a number of different locations in the mining districts of Mitsero but also Xyliatos shows that this must have been the case indeed (Kassianidou, 2012b, p.101). Nevertheless, the impact of these workshops on the landscape would not have been significant.

The matte produced at Phorades would have to be converted into copper metal. This second stage in the process does not seem to have taken place in the same workshop and this may explain the presence of significant metallurgical workshops within the most important urban centre of this earliest phase of the Late Bronze Age, namely Enkomi which is located on the east coast of the island. Enkomi is the most cosmopolitan port town on the island throughout the Late Bronze Age. Some scholars suggest that it is very probable that at least for the first half of the Late Bronze Age it was the capital of Cyprus and the seat of the king of Alashiya (e.g. Peltenburg, 1996, p.35; Muhly, 1989, p.303).

Excavations in the north part of the city uncovered a very large building the earliest occupation which is contemporary to the Phorades workshop (Crewe, 2007, p.75). From its foundation and throughout most of its history this building was dedicated to metallurgical activities (Kassianidou, 2012b). Although it may seem irrational today that matte or black copper would have been carried from the ore bearing and forested regions of the Troodos foothills all the way to Enkomi which is located on the East coast of the island (for example Phorades is about 60km West - as the crow flies - of Enkomi), it is not impossible. Dikaios (1969, p.10), who was trying to understand the presence of extensive metallurgical workshops in Enkomi wrote in his introductory chapter:

"*Catling suggests that Enkomi drew its supplies of copper ore from the industrial site of Troulli, ten miles north of Larnaca, rather than from the distant Troodos hills. This may be so but the second alternative may be equally possible. In support of this I may quote the following instance: Until about fifty years ago* (since Dikaios' book was published in 1969 this would correspond to the 1920s), *before the introduction to Cyprus of mechanical production of ice, villagers from the village of Prodromos which lies below the Troodos summit, used to carry to Nicosia, during the summer season, ice, on donkey back, from pits on the highest summit of Troodos, in which snow accumulated during the winter and where it was carefully preserved until the summer. According to information given to me by old inhabitants of Prodromos, they loaded the donkeys at sunset and travelled all the way down to the plain along short cuts across hill country, reaching Nicosia on the following morning. If then ice could be carried from the summit of Troodos to Nicosia in one night, surely copper ore could be transported to Enkomi from the Skouriotissa and other mines which lie on the northern foothills of Troodos, during the same*

length of time or somewhat longer. There were, probably organized convoys of donkeys or mules carrying regularly ore to industrial towns such as Enkomi and others".

It is very likely that in these workshops at Enkomi the final stages of the copper production would have taken place including the casting of the metal in the form of oxhide ingots. Recently published Lead Isotope Analysis data indicate that already from the fifteenth century BC Cypriot copper was cast into the shape of oxhide ingots and exported to Crete (Stos-Gale, 2011, p.223).

During the following centuries the scale of production and export intensified significantly as indicated by the discovery of the Uluburun shipwreck which among other things was carrying the staggering amount of 10 tons of copper in the form of oxhide and bun ingots (Pulak, 2008; Pulak, 2005). According to LIA analysis the most likely source for the metal of both the oxhide and the bun ingots is Cyprus (Stos, 2009, pp.172-173). The cargo is similar in scale to shipments of copper mentioned in the letters from the king of Alashiya which were found in the well-known archive of Tel el Amarna (Moran, 1992, pp.104-113). Indeed the fact that among those who correspond with the pharaoh, the king of Alashiya is the only one who sends copper, has often been used as an argument to support the identification of Alashiya with Cyprus (Knapp, 1996, p.8; Muhly, 1996, p.49). In the letter EA35 the king of Alashiya apologizes for sending only 500 unspecified units, (but most probably they are talents (Moran, 1992, p.150)) of copper explaining that this is because the god Nergal has "*slain all the men in my country, and there is not a (single) copper-worker*" (Moran, 1992, p.107). This shows that the copper was locally produced and sent directly from Alashiya to Egypt. According to Moran (1992, p.108) it is not clear whether by copper-worker the king is referring to a miner or to a copper refiner. Unfortunately, no copper mines or primary smelting workshops dating to the 14th century BC are known to date. The Enkomi workshops, however, were still as active as ever (Dikaios, 1971, p.505).

Things are very different in the thirteenth century BC which corresponds to the Late Cypriot IIC. This is the period that has produced the majority of the evidence for copper production on the island. It is in this period that the sole mining settlement, the famous Apliki *Karamallos,* is dated (Du Plat Taylor, 1952; Kling and Muhly, 2007). The mine of Apliki is well known because, according to Lead Isotope Analysis, it is most probably the mine that generated the copper used to produce the vast majority of copper oxhide ingots found in Cyprus and abroad (Gale, 2011, p.218). The Apliki mine lies within Cyprus' richest mining district, defined in the publications of Gale and Stos Gale as the Solea axis deposits, which include the mines of Mavrovouni and Skouriotissa (Stos-Gale et al., 1997). In modern times the three mines produced more than 85% of the total copper ore concentrate that was exported from Cyprus (Constantinou, 1982, p.15). Furthermore, based on the size of the slag heaps it is estimated that during the antiquity this area probably produced more than 50% of the total amount of copper produced on the island (Constantinou, 2007, p.339). The average copper content in these three ore deposits varies from 2 - 4,5 % but in the secondary enrichment zone which is the one that would have been exploited by the ancients it reached as much as 20% (Constantinou, 2007, p.342). The ore deposits were not only rich in copper they were also easy to mine. According to Constantinou (2007, p.341*):"The human energy necessary for the mining of one ton of conglomeratic ore from these three orebodies* (he means Apliki, Mavrovouni and Skouriotissa) *of this area is orders of magnitude less than that required for the mining of the same amounts of massive sulphide ore from Ergani Maden (Turkey), Ermioni (Greece). Jabel Said (Saudi Arabia), Rio Tinto (Spain) or the copper ores from Timna and Feinan."* Skouriotissa is the only copper mine still operating today and a modern plant is now producing very pure metallic copper on the island for the first time since Antiquity. Mavrovouni lies in the Turkish occupied area since the 1974 Turkish military invasion of the island and Apliki lies in the UN buffer zone and is thus only accessible with a special permit from the United Nations Task Force in Cyprus. Fig 4 is a photograph taken from the top of the Skouriotissa open cast mine which shows the spatial relationship between the three mines. The location of Apliki and Mavrovouni is marked by the enormous modern spoil heaps and the scar left by the Mavrovouni opencast. The landscape is rather bare today, because most of the forest burned down during the 1974 invasion. It would have been wooded and lush in Antiquity, as it was in the more recent past. This is because of the abundance of water – even today the Karyiotis river which passes through this area is one of the few on the island that does not run dry in the summer. Apliki is less than eight kilometres away from the coast where in modern times the Cyprus Mines Corporation set up a pier to ship the copper concentrates from these three mines out.

The site of Apliki *Karamallos* was discovered in 1938 when modern mining operations uncovered the remains of buildings. It was partly excavated in 1938 and 1939 by Joan Du Plat Taylor and was subsequently destroyed (Kling and Muhly, 2007, xi). The rescue exca-

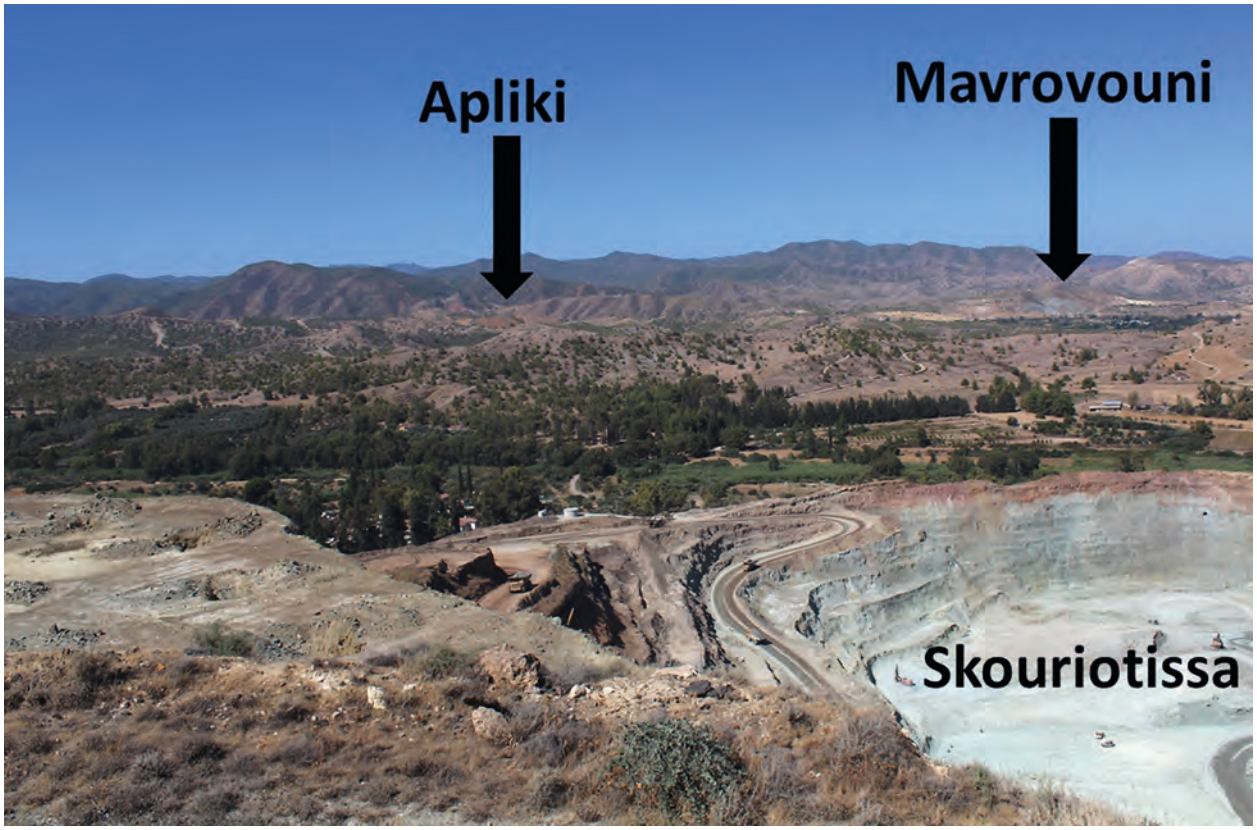


Fig. 4: View from the open cast of Skouriotissa which can been seen in the foreground. In the distance are the mines of Apliki and Mavrovouni.

vations brought to light a couple of houses, where, apart from large storage vessels, numerous stone tools were found including perforated stone hammers and heavy pestles which clearly were related to the processing of ores (Kassianidou, 2007). The finds also include tap slag and tuyères which are massive (Muhly, 1989, p.309). All the evidence shows that the ore extracted from the nearby mine was processed and smelted to produce copper metal somewhere on the hill of *Karamallos*. Unfortunately no evidence of Late Bronze Age exploitation was recorded in the mine itself but it must have been extensive. Nor were any smelting installations dating to the Late Bronze Age uncovered in the excavated areas. Furthermore, the material culture recovered in the rooms that were excavated was modest. According to Webb (2007, p.271) the archaeological assemblage shows that elite goods acquired from coastal emporia did not reach the settlement. What did reach the inhabitants are some basic agricultural produce, such as hulled six-row barley, bread wheat, horsebean, lentils, grapes, olives and coriander which could not be cultivated on the hill of *Karamallos* (Helbaek, 1962, pp.185-186). This led Webb (2007, p.271) to conclude that Apliki *Karamallos* seems to be: "*a relatively small-scale venture operating within a local exchange system in which relations with agricultural villages which supplied basic foodstuffs and other essential commodities were of more immediate import than those with more distant coastal centers*".

Apliki was not the only copper ore deposit to be exploited in this period. Lead Isotope Analysis shows that several bronze artefacts from a number of Late Cypriot IIC sites are consistent with other Cypriot ore deposits (Gale and Stos-Gale, 2012, p.71). Unfortunately no Late Bronze Age mines or primary smelting sites have yet been discovered in any of the other mining regions for the reasons outlined in the beginning of this paper. The vibrant Cypriot copper industry of the 13th century is clearly illustrated by the abundance of archaeometallurgical finds such as slag, tuyères and crucible fragments that have been recovered in other, contemporary Late Cypriot IIC settlements, such as Kalavasos *Ayios Dhimitrios* (South, 2012) and Alassa *Pano Mandilaris* (Hadjisavvas, 2011). Both are in close proximity to important copper ore deposits and presumably both would have been involved in the exploitation of these deposits. The most extensive workshops, however, have been found in Area III of Enkomi, where a new building is erected in this period (Dikaios, 1969, p.46). The western sector of the building constituted a group of copper workshops, organized around a central court, where according to Dikaios (1969, p.56) an unprecedented intensification of metallurgical activity was evident.

Unfortunately very little is known regarding the organization of the copper industry in this period because the political organization of the island remains unclear (for a recent review of the evidence see Knapp (2008, pp.131-172)). Namely, it is not known whether in the thirteenth century BC the island is still a single political entity governed by a single king, (based in Enkomi?) or whether it has already started to break up into smaller regional polities which eventually developed to the Iron Age kingdoms. In the first case the copper extracted from the mine of Apliki would have to be transported overland, on a donkey caravan, like the one described by Dikaios, to Enkomi, where it was cast into oxhide ingots and then exported. In the latter case the oxhide ingots could have been produced at Apliki and exported from a yet unknown harbour town that would have been located on the coast below. This may have been the predecessor of the kingdom of Soloi, one of Cyprus' most important and wealthiest Iron Age kingdoms.

At the end of the thirteenth century BC many of the settlements such as Kalavasos *Ayios Dhimitrios* and Alassa are abandoned (Karageorghis, 2012, p.73). Enkomi, however, even in the twelfth century, was an important harbour town and still active in copper production and presumably export. Although the workshops in Area III were abandoned, many others were established in other sectors of the town (Courtois, 1982, pp.160-162). Copper was still being cast in the form of oxhide ingots and according to the Lead Isotope Analysis the metal source was still the mine of Apliki, although the settlement of Apliki *Karamallos* had also been abandoned by this time (Manning and Kuniholm, 2007, p.328). In the 11th century the Late Bronze Age comes to an end but not the production and trade of Cypriot copper which continues to thrive during the Iron Age (Kassianidou, 2012c, pp.231-237).

Conclusion

From the earliest phase of human occupation on Cyprus the island's mineral wealth was systematically exploited. The extent of the human impact on the natural environment can only be indirectly identified by compiling archaeological evidence regarding the intensity of copper production. For example the size of the Uluburun copper cargo, which is estimated to be 10 tons, clearly shows that already by the 14th century BC the ore deposits were intensively and systematically exploited. The copper industry would have played a significant role in the transformation of the natural landscape to an industrial landscape which would have been characterized by the gradual depletion of the forests and the presence of small scale smelting workshops scattered around the mining regions of the islands. Cyprus' political topography would also gradually change because of the copper industry, as new settlements, for the miners and smiths were established in areas which were not extensively inhabited in the past. Today very little survives of these prehistoric mining landscapes which were gradually obliterated first by the industrial scale copper industry of the Roman period and then with the shift to open cast mining in the twentieth century. It is always the hope that remnants, such as the copper smelting workshop of *Phorades*, have escaped and are waiting to be systematically recorded and excavated.

References

Aloupi, E., Karydas, A. G. and Paradellis, T., 2000. Pigment analysis of wall paintings and ceramics from Greece and Cyprus: The optimum use of X-Ray Spectrometry on specific archaeological issues, *X-Ray Spectrometry*, 29, pp.18–24.

Bear, L.M., 1963. *The Mineral Resources and Mining Industry of Cyprus* (Geological Survey Department Bulletin 1). Nicosia.

Belgiorno, M.R., Ferro, D. and Loepp, D.R., 2012. Pyrgos-Mavrorachi in Cypriot metallurgy. In: V. Kassianidou, and G. Papasavvas eds. 2012, Eastern *Mediterranean Metallurgy and Metalwork in the Second Millennium BC*. Oxford, pp.26-34.

Bruce, J.L., 1948. Cyprus mines copper again. *Mining Technology,* A.I.M.E. Technical Publication no. 2459.

Bruce, J.L., 1937. Appendix V. Antiquities in the mines of Cyprus. In: E. Gjerstad, J. Lindros, E. Sjoqvist, and A. Westholm, eds. 1937. *The Swedish Cyprus Expedition: Finds and Results of the Excavations in Cyprus* 1927-1931. Volume III. Stockholm, pp.639-7.

Coleman, J.E., Barlow, J.A., Mogelonsky, M.K. and Schaar, K.W., 1996. *Alambra, A Middle Bronze Age Settlement in Cyprus: Archaeological Investigations by Cornell University 1974 – 1985* (Studies in Mediterranean Archaeology, CXVII). Jonsered.

Constantinou, G., 2012. Late Bronze Age copper production in Cyprus from a mining geologist's perspective. In: V. Kassianidou and G. Papasavvas, eds. 2012. *Eastern Mediterranean Metallurgy and Metalwork in the Second Millennium BC*. Oxford and Oakville, pp.4-13.

Constantinou, G., 2007. Contribution of the geology to the early exploitation of the cupriferous sulphide deposits of the Skouriotissa mining district. In: B. Kling and J.D. Muhly. *Joan du Plat Taylor´s Excavations at the Late Bronze Age Mining Settlement at Apliki Karamallos, Cyprus* (Studies in Mediterranean Archaeology, Volume 94,1). Sävedalen, pp.337-345.

Constantinou, G., 1992a. The mining industry of Cyprus in modern times. In: A. Marangou and K. Psillides, eds. 1992. *Cyprus Copper and the Sea.* Nicosia, pp.328-367

Constantinou, G., 1992b. Ancient copper mining in Cyprus. In: A. Marangou and K. Psillides, eds. 1992. *Cyprus Copper and the Sea.* Nicosia, pp.44-75.

Constantinou, G., 1982. Geological features and ancient exploitation of the cupriferous sulphide orebodies of Cyprus. In: J.D. Muhly, R. Maddin and V. Karageorghis, eds. 1982. *Early Metallurgy in Cyprus 4000 - 500 BC*. Nicosia, pp.13-23.

Courtois, J. C., 1982. L´ activité métallurgique et les bronzes d´ Enkomi au Bronze Récent (1650-1100 avant J.C). In: J. D Muhly, R. Maddin and V. Karageorghis, eds. 1982. *Early Metallurgy in Cyprus 4000-500 BC*. Nicosia, pp.155-174.

Crewe, L., 2007. *Early Enkomi: Regionalism, Trade, and Society at the Beginning of the Late Bronze Age on Cyprus* (BAR International Series 1706). Oxford.

Dikaios, P., 1971. *Enkomi. Excavations 1948-1958. Volume II.* Mainz.

Dikaios, P., 1969. *Enkomi. Excavations 1948-1958. Volume I.* Mainz.

Dikaios, P., 1946. A new chapter in the long history of Cyprus: Wartime discoveries of the earliest Copper Age. *Illustrated London News,* 2 March, 208(5576), pp.244-245.

Du Plat Taylor, J., 1952. A Late Bronze Age settlement at Apliki, Cyprus. *The Antiquaries Journal*, XXXII, pp.133-167.

Edwards, S., Hudson-Edwards, K., Cann, J., Malpas, J. and Xenophontos, C., 2010. *Cyprus* (Classic Geology in Europe 7). Harpenden.

Falconer, S.E. and Fall, P.L., 2013. Household and community behavior at Bronze Age Politiko-Troullia, Cyprus. *Journal of Field Archaeology*, 38(2), pp.101-119.

Gale, N.H., 2011. Copper oxhide ingots and lead isotope provenancing. In: P. P. Betancourt and S. Ferrence, eds. 2011. *Metallurgy Understanding How, Learning Why: Studies in Honor of James D. Muhly* (Prehistory Monographs 29). Philadelphia, pp.213-220.

Gale, N.H., Stos-Gale, S., 2012. The role of the Apliki mine region in the post c. 1400 BC copper production and trade networks in Cyprus and in the wider Mediterranean. In: V. Kassianidou and G. Papasavvas, eds. 2012. *Eastern Mediterranean Metallurgy and Metalwork in the Second Millennium BC.* Oxford, pp.70-82.

Gale, N.H., Stos-Gale, S. and Fasnacht, W., 1996. Metal and metalworking In: J.E. Coleman, J.A. Barlow, M.K. Mogelonsky and K.W. Schaar, 1996. *Alambra, A Middle Bronze Age Settlement in Cyprus: Archaeological Investigations by Cornell University 1974 – 1985* (Studies in Mediterranean Archaeology, CXVII). Jonsered, pp.129-142.

Hadjisavvas, S., 2011. Broken symbols: Aspects of metallurgy at Alassa In: P.P. Betancourt and S. C. Ferrence, eds. 2011. *Metallurgy: Understanding How, Learning Why: Studies in Honor of James D. Muhly* (Prehistory Monographs 29). Philadelphia, pp.21-27.

Helbaek, H., 1962. Late Cypriote vegetable diet at Apliki, *Opuscula Atheniensia*, 4, pp.171-186.

Karageorghis, V., 2002. Early Cyprus. *Crossroads of the Mediterranean.* Los Angeles.

Kassianidou, V., 2013. Chapter 6 – Metals. In: E. Peltenburg, ed., 2013. ARCANE II. *Cyprus*. Turnhout, pp.231-249.

Kassianidou, V., 2012a. Parallels and diversities in the production, trade and use of copper and iron in Crete and Cyprus from the Bronze Age to the Iron Age: the view from Cyprus. In: G. Cadogan, M. Iacovou, K. Kopaka and J. Whitley, eds. 2012. *Parallel Lives: Ancient Island Societies in Crete and Cyprus.* London, pp.126-140.

Kassianidou, V., 2012b. Metallurgy and metalwork in Enkomi: the early phases. In: V. Kassianidou and G. Papasavvas, eds., 2012. *Eastern Mediterranean Metallurgy and Metalwork in the Second Millennium BC*. Oxford and Oakville, pp.94-106.

Kassianidou, V., 2012c. The origin and use of metals in Iron Age Cyprus. In: M. Iacovou, ed.. *Cyprus and the Aegean in the Early Iron Age: The Legacy of Nicolas Coldstream,* Nicosia, pp.229-259.

Kassianidou, V., 2011a. The production of copper in Cyprus during the Roman Period. In: A. Demetriou, ed. 2011. *Proceedings of the Fourth International Cyprological Conference (Nicosia, 29 April –3 May 2008)*. Volume A´- Ancient Section. Nicosia, pp.539-548.

Kassianidou, V., 2011b. Blowing the wind of change: the introduction of bellows in Late Bronze Age Cyprus. In: P.P. Betancourt and S. C. Ferrence, eds. 2011. *Metallurgy: Understanding How, Learning Why: Studies in Honor of James D. Muhly* (Prehistory Monographs 29). Philadelphia, pp.41-47.

Kassianidou, V., 2008. The formative years of the Cypriot copper industry. In: I. Tzachilli, ed. 2008. *Aegean Metallurgy in the Bronze Age.* Athens, pp.249-267.

Kassianidou, V., 2007. Ground stone tools from Apliki Karamallos. In: B. Kling and J.D. Muhly, *2007. Joan du Plat Taylor´s Excavations at the Late Bronze Age Mining Settlement at Apliki Karamallos, Cyprus* (Studies in Mediterranean Archaeology, Volume 94:1). Sävedalen, pp.277-306.

Kling, B. and Muhly, J.D., 2007. *Joan du Plat Taylor´s Excavations at the Late Bronze Age Mining Settlement at Apliki Karamallos, Cyprus* (Studies in Mediterranean Archaeology 94:1). Sävedalen.

Knapp, A.B., 2011. Cyprus, copper and Alashiya. In: P.P. Betancourt and S. C. Ferrence, eds. 2011. *Metallurgy: Understanding How, Learning Why: Studies in Honor of James D. Muhly* (Prehistory Monographs 29). Philadelphia, pp.249-254.

Knapp, A.B., 2008. *Prehistoric & Protohistoric Cyprus.* Oxford.

Knapp, A.B., 2003. SIA 7: Politiko *Kokkinorotsos*. In: M. Given and A.B. Knapp, 2003. *The Sydney Cyprus Survey Project: Social Approaches To Regional Archaeological Survey* (Monumenta Archaeologica 21). Los Angeles, pp.130-146.

Knapp, A.B., 1996. Introduction. In: A. B. Knapp, ed. 1996. *Sources for the History of Cyprus, Volume II: Near Eastern and Aegean Texts from the Third to the First Millennia BC.* Altamont, New York, pp.1-13.

Knapp, A.B. and Kassianidou, V., 2008. The archaeology of Late Bronze Age copper production: Politiko Phorades on Cyprus. In: Ü. Yalçin, ed. 2008. *Anatolian Metal IV* (Der Anschnitt Beiheft 21). Bochum, pp.135-147.

Manning, S. W. and Kuniholm, P.I., 2007. Absolute dating at Apliki Karamallos. In: B. Kling and J.D. Muhly, 2007. *Joan du Plat Taylor´s Excavations at the Late Bronze Age Mining Settlement at Apliki Karamallos, Cyprus* (Studies in Mediterranean Archaeology, Volume 94:1). Sävedalen, pp.325-335.

McCartney, C., Manning, S. W. and Stewart, S.T., 2010. *Agia Varvara-Asprokremmos* 2009: Excavations, radio-carbon dating and geo-chemical analysis of chert sources (Report of the Department of Antiquities). Cyprus, pp.77-94.

Merrillees, R.S., 1984. Ambelikou *Aletri:* A preliminary report (Report of the Department of Antiquities). Cyprus, pp.1-13.

Michaelides, D., 1996. The economy of Cyprus during the Hellenistic and Roman periods. In: D. Michaelides and V. Karageorghis, eds. 1996. *The Development of the Cypriot Economy from the Pre-historic Period to the Present Day.* Nicosia, pp.139-152.

W. L. Moran, 1992. *The Amarna Letters*. Baltimore and London.

Muhly, J.D., 1996. The significance of metals in the Late Bronze Age economy of Cyprus. In: V. Karageorghis and D. Michaelides, eds. 1996. *The Development of the Cypriot Economy from the Prehistoric Period to the Present Day.* Nicosia, pp.45-60.

Muhly, J.D., 1989. The organisation of the copper industry in Late Bronze Age Cyprus. In: E. Peltenburg, ed. 1989. *Early Society in Cyprus.* Edinburgh, pp.298-314.

Panayiotou, A., 1989. Μεταλλεία (Mines in Greek). In: Μεγάλη Κυπριακή Εγκυκλοπαίδεια (The Great Cypriot Encyclopedia) 10. Nicosia, pp.31-43.

Peltenburg, E., 2012a. Souskiou. In: D. Pilides and N. Papadimitriou, eds. 2012. *Ancient Cyprus – Cultures in Dialogue.* Nicosia, pp.48-47.

Peltenburg, E., 2012b. East Mediterranean water wells of the 9th –7th millennium BC. In: F. Klimscha, R. Eichmann, C. Schuler and H. Fahlbusch, eds. 2012. *Wasserwirtschaftliche Innovationen im archäologischen Kontext: Von den prähistorischen Anfängen bis zu den Metropolen der Antike.* Leidorf, pp.69-82.

Peltenburg, E., 2011. Cypriot Chalcolithic metalwork. In: P. P. Betancourt and S. C. Ferrence, eds. 2011. *Metallurgy: Understanding How, Learning Why: Studies in Honor of James D. Muhly* (Prehistory Monographs 29). Philadelphia, pp.3-10.

Peltenburg, E., 1996. From isolation to state formation in Cyprus c. 3500-1500 BC. In: V. Karageorghis and D. Michaelides, eds. 1996. *The Development of the Cypriot Economy: From the Prehistoric Period to the Present Day.* Nicosia, pp.45-60.

Peltenburg, E., 1991. Local exchange in prehistoric Cyprus: An initial assessment of picrolite (Bulletin of the American School of Oriental Research 282/283), pp.107-126.

Pickles, S. and E. Peltenburg, 1998. Metallurgy, society and the Bronze/Iron transition in the East Mediterranean and the Near East (Report of the Department of Antiquities). Cyprus, pp.67-100.

Pulak, C., 2008. The Uluburun shipwreck and Late Bronze Age trade. In: J. Aruz, K. Benzel and J.M. Evans, eds. 2008. Beyond Babylon. Art, Trade and Diplomacy in the Second Millennium B.C. New York, New Haven and London, pp.289-385.

Pulak, C., 2005. Das Schiffswrack von Uluburun. In: Ü. Yalçin, C. Pulak and R. Slotta, eds. 2005. *Das Schiff von Uluburun: Welthandel vor 3000 Jahren.* Bochum, pp.55-102.

Rickard, T.A., 1930. Copper mining in Cyprus (Transactions of the Institution of Mining and Metallurgy 39), pp.285–301.

South, A., 2012. Tinker, tailor, farmer, miner: Metals in the Late Bronze Age economy at Kalavasos. In: V. Kassianidou and G. Papasavvas, eds. 2012. *Eastern Mediterranean Metallurgy and Metalwork in the Second Millennium BC.* Oxford and Oakville, pp.35-47.

South, A. and Todd, I.A., 2005. Wall painting/painted plaster. In: I.A. Todd, 2005. *Vasilikos Valley Project 7: Excavations at Kalavasos-Tenta.* Volume II (Studies in Mediterranean Archaeology Vol. LXXI:7). Sävedalen, pp.313-314.

Stos, Z.A., 2009. Across the wine dark seas…Sailor tinkers and royal cargoes in the Late Bronze Age Eastern Mediterranean. In: A.J. Shortland, I.C. Freestone and Th. Rehren, eds. 2009. *From Mine to Microscope: Advances in the Study of Ancient Technology*. Oxford, pp.163-180.

Stos-Gale, Z.A., 2011. 'Biscuits with ears': A search for the origin of the earliest oxhide ingots. In: P.P. Betancourt and S. C. Ferrence, eds. 2011. *Metallurgy: Understanding How, Learning Why: Studies in Honor of James D. Muhly* (Prehistory Monographs 29). Philadelphia, pp.221-229.

Stos-Gale, Z.A., Maliotis, G., Gale, N.H. and Annetts, N., 1997. Lead isotope characteristics of the Cyprus copper deposits applied to provenance studies of copper oxhide ingots, *Archaeometry*, 39, pp.83-124.

Webb, J.M., 2007. Stamp seal of serpentine from Apliki Karamallos. In: B. Kling and J.D. Muhly 2007. *Joan du Plat Taylor´s Excavations at the Late Bronze Age Mining Settlement at Apliki Karamallos, Cyprus* (Studies in Mediterranean Archaeology, Volume 94,1). Sävedalen, pp.269-275.

Webb, J.M. and Frankel, D., 2013. *Ambelikou Aletri: Metallurgy and Pottery Production in Middle Bronze Age Cyprus* (Studies in Mediterranean Archaeology Vol. CXXXVIII). Uppsala.

Webb, J.M. and Frankel, D., 1999. Characterizing the Philia facies: Material culture, chronology and the origin of the Bronze Age in Cyprus, *American Journal of Archaeology*, 103, pp.3–43.

Xenophontos, C., 1991. Picrolite, Its nature, provenance, and possible distribution patterns in the Chalcolithic period of Cyprus (Bulletin of the American School of Oriental Research 282/283), pp.127-138.WEBB, J.M. and FRANKEL, D., 2013. *Ambelikou Aletri: Metallurgy and Pottery Production in Middle Bronze Age Cyprus* (Studies in Mediterranean Archaeology Vol. CXXXVIII). Uppsala.

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